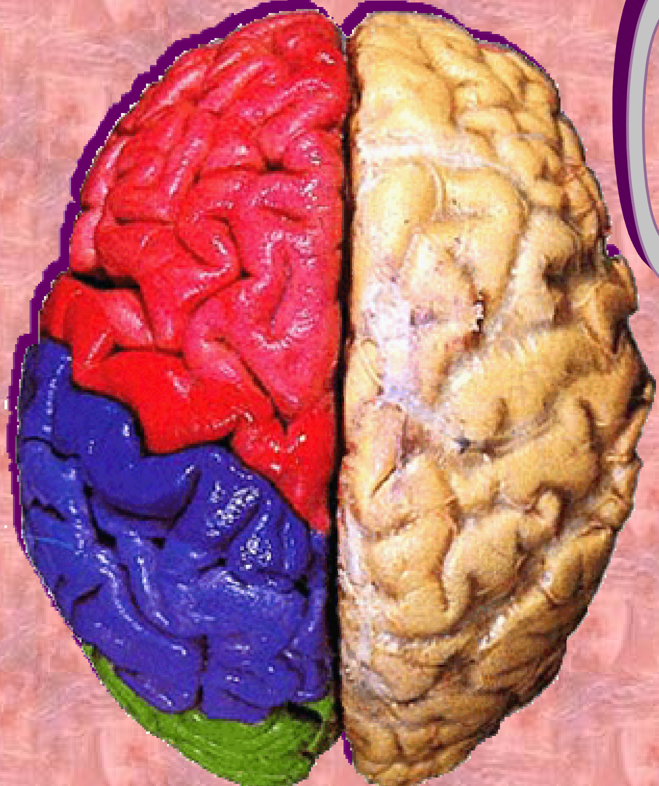
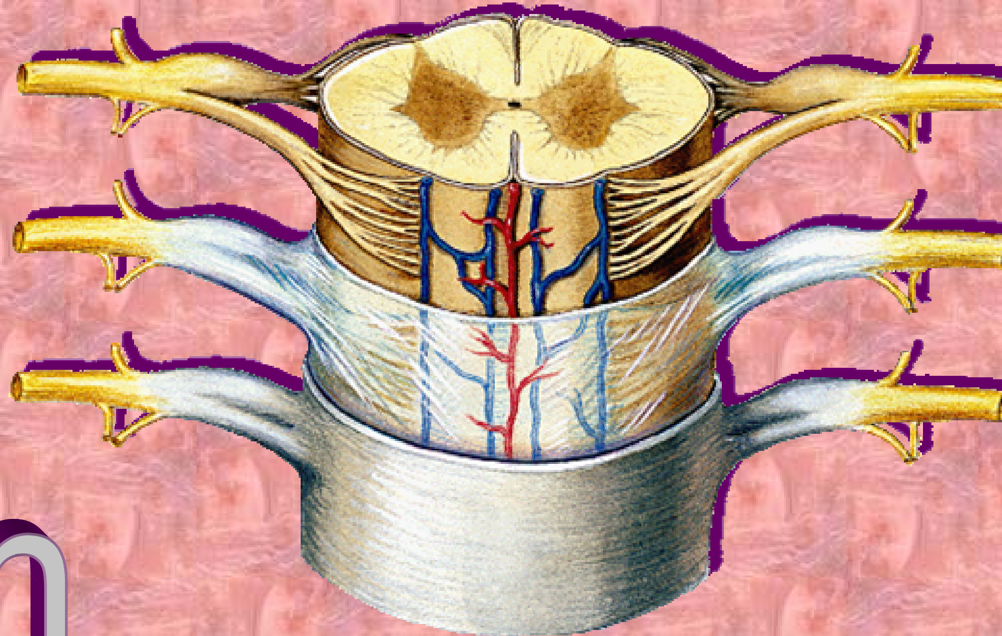
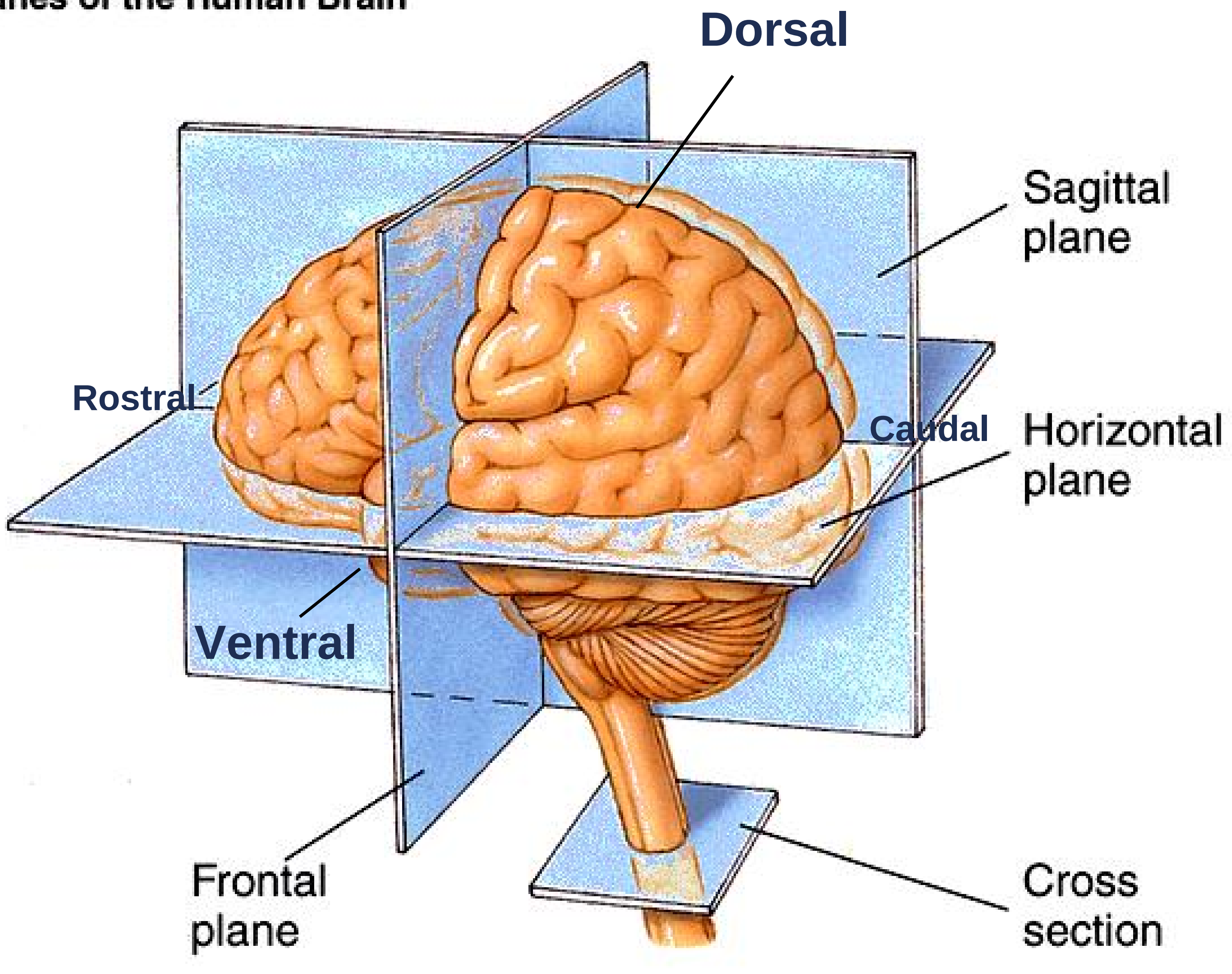
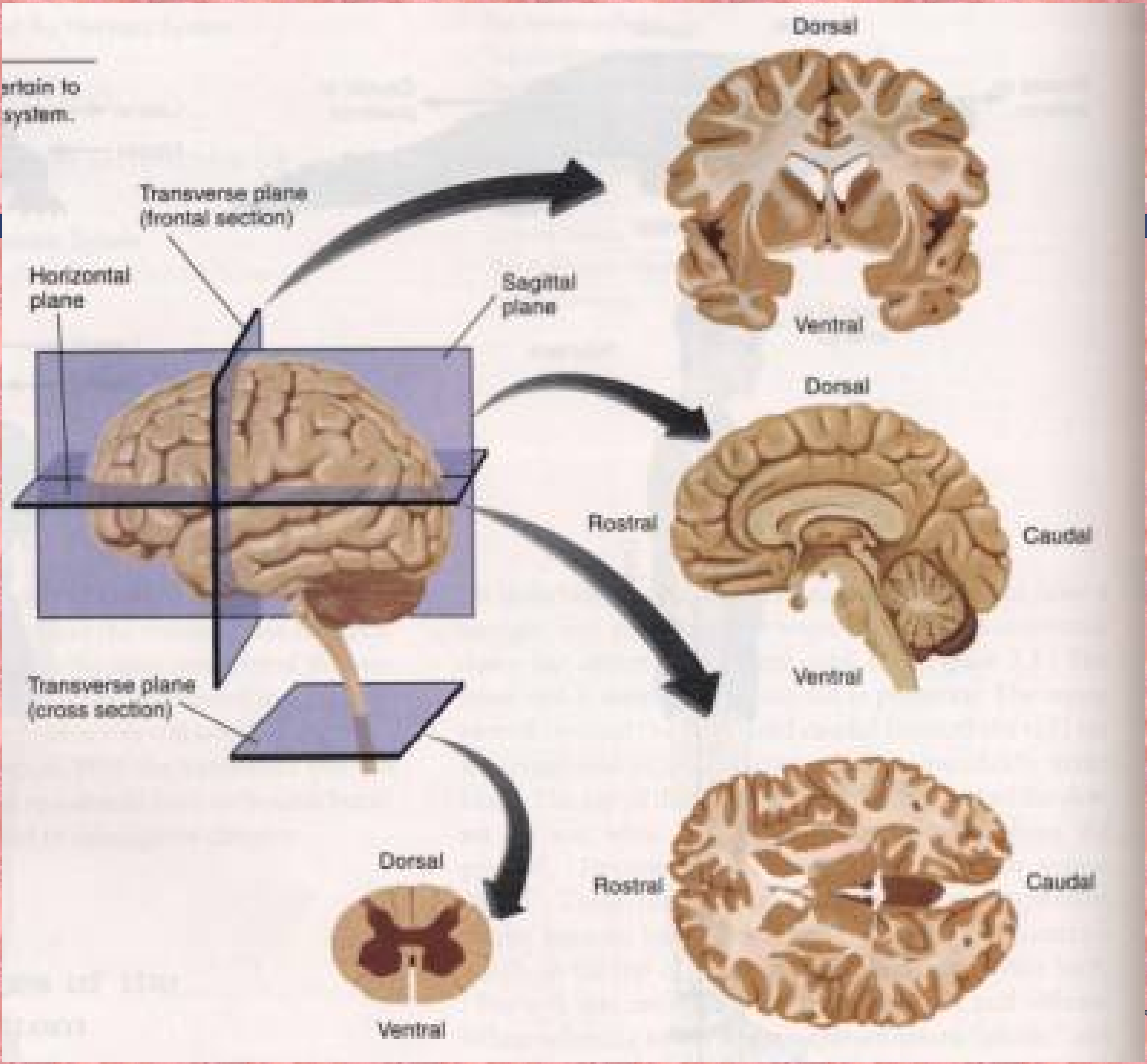
The Central Nervous System





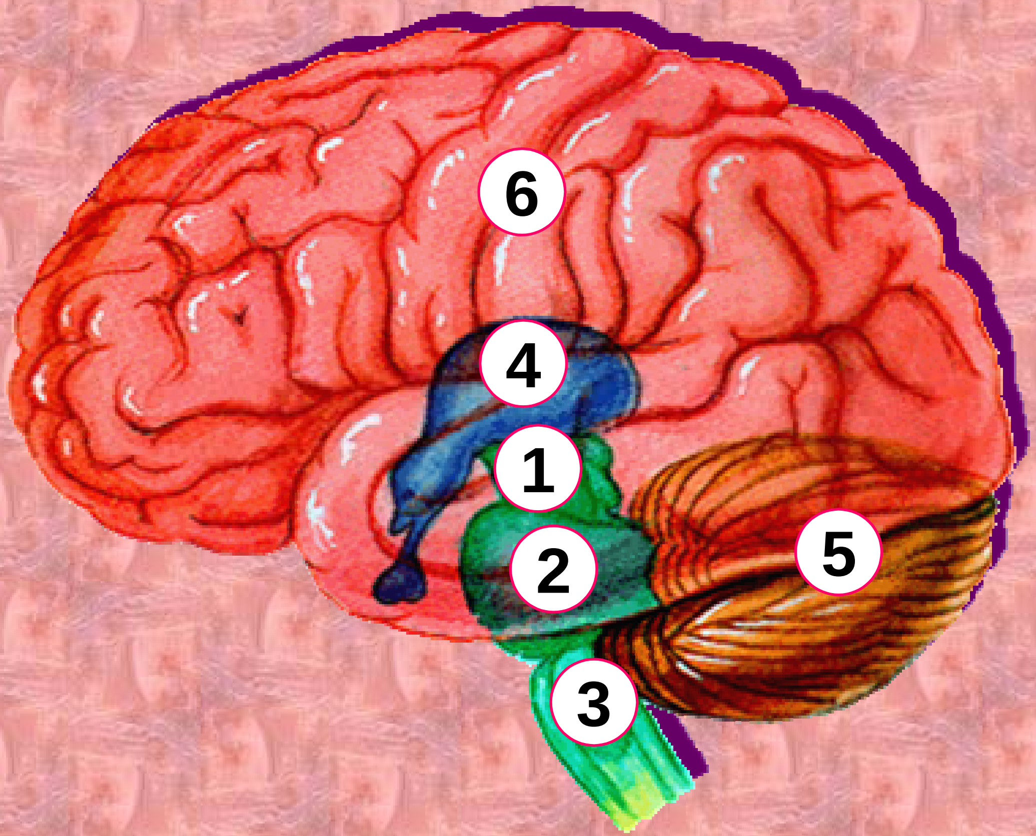
► **Planes of the Human Brain**




ertain to
system.
Transverse plane
(frontal section)
Horizontal
plane
Sagittal
plane
Transverse plane
(cross section)
Dorsal
Ventral
Dorsal
Rostral
Caudal
Ventral
Rostral
Caudal
Dorsal
Ventral

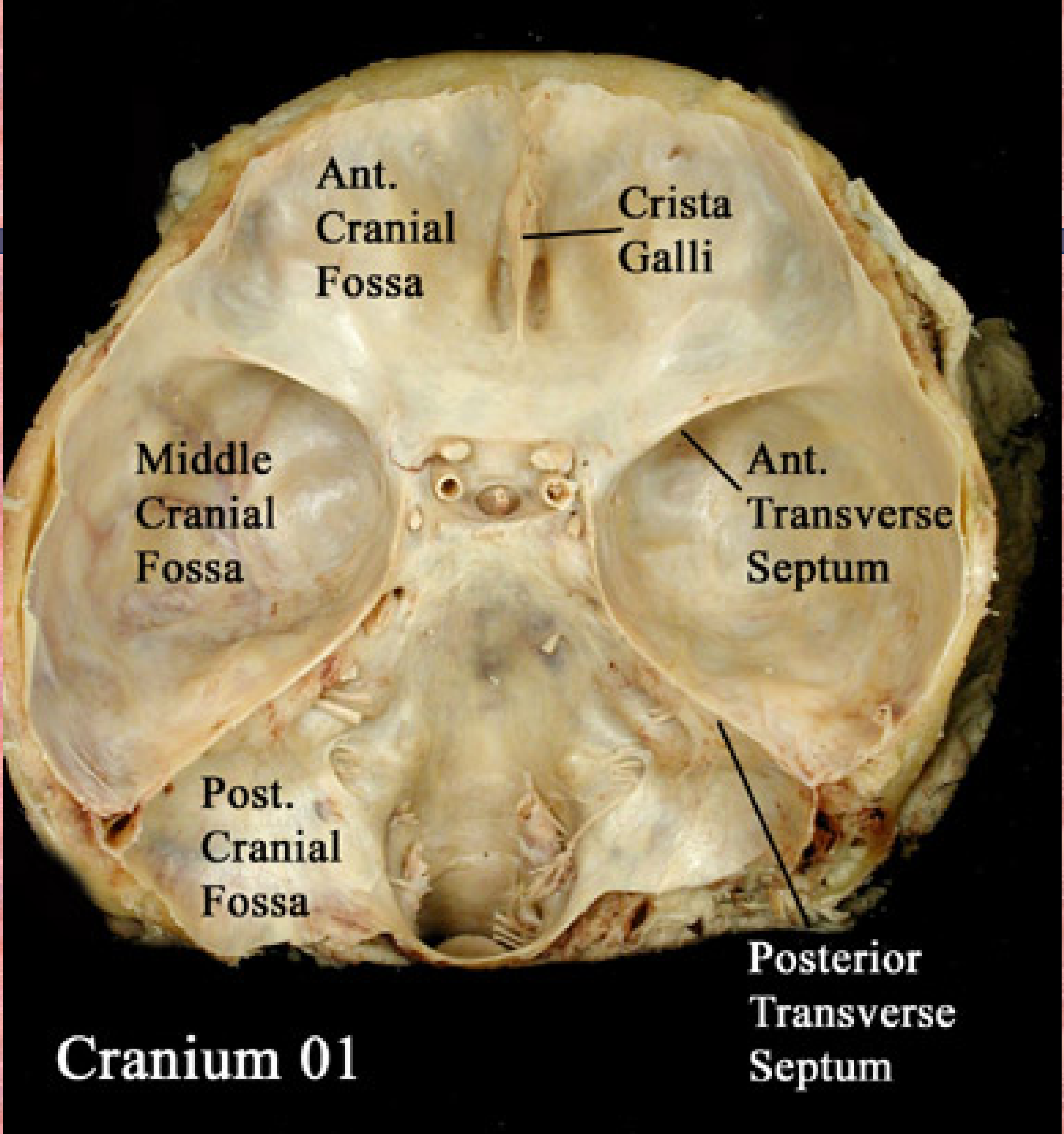
Divisions of the Brain

- Brainstem
  - Medulla oblongata (1)
  - Pons (2)
  - Midbrain (3)
- Diencephalon (4)
  - Thalamus
  - Hypothalamus
  - Epithalamus
- Cerebellum (5)
- Cerebrum (6)



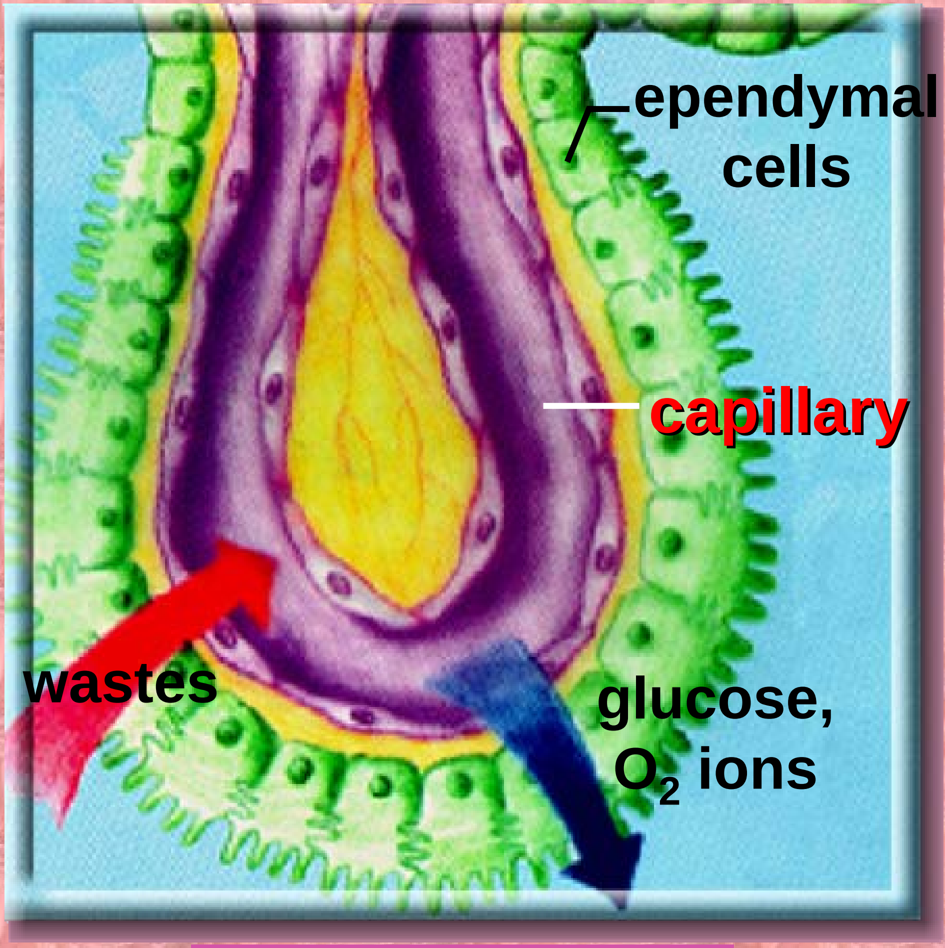
Protection of the CNS

- **Structures that help to protect the brain and spinal cord:**
  - **Skull bones**
  - **Vertebrae**
  - **Cerebrospinal Fluid (CSF)**
    - **Bathes and cushions**
  - **Meninges**
    - **Three connective tissue membranes surrounding the brain and spinal cord**


Ant.
Cranial
Fossa
Crista
Galli
Middle
Cranial
Fossa
Ant.
Transverse
Septum
Post.
Cranial
Fossa
Posterior
Transverse
Septum
Cranium 01

Cerebrospinal Fluid

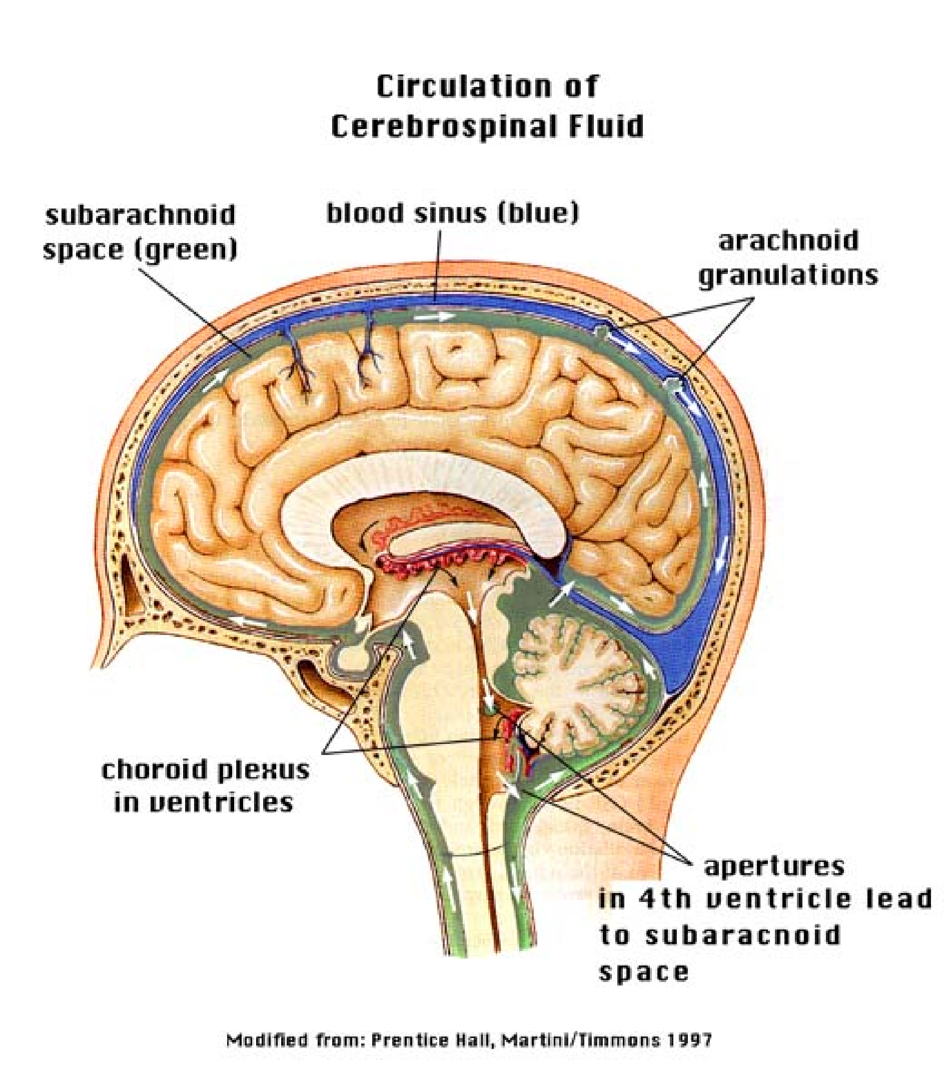
- **Flows around and in the brain and spinal cord**
- **99% water**
- **Also sugar (glucose), chlorides, proteins, ions, vitamin C**
- **Total volume of 150 ml (replaced every 3 to 4 hrs.)**
- **900 to 1200 ml formed daily**
- **Formed by choroid plexuses in the brain ventricles**

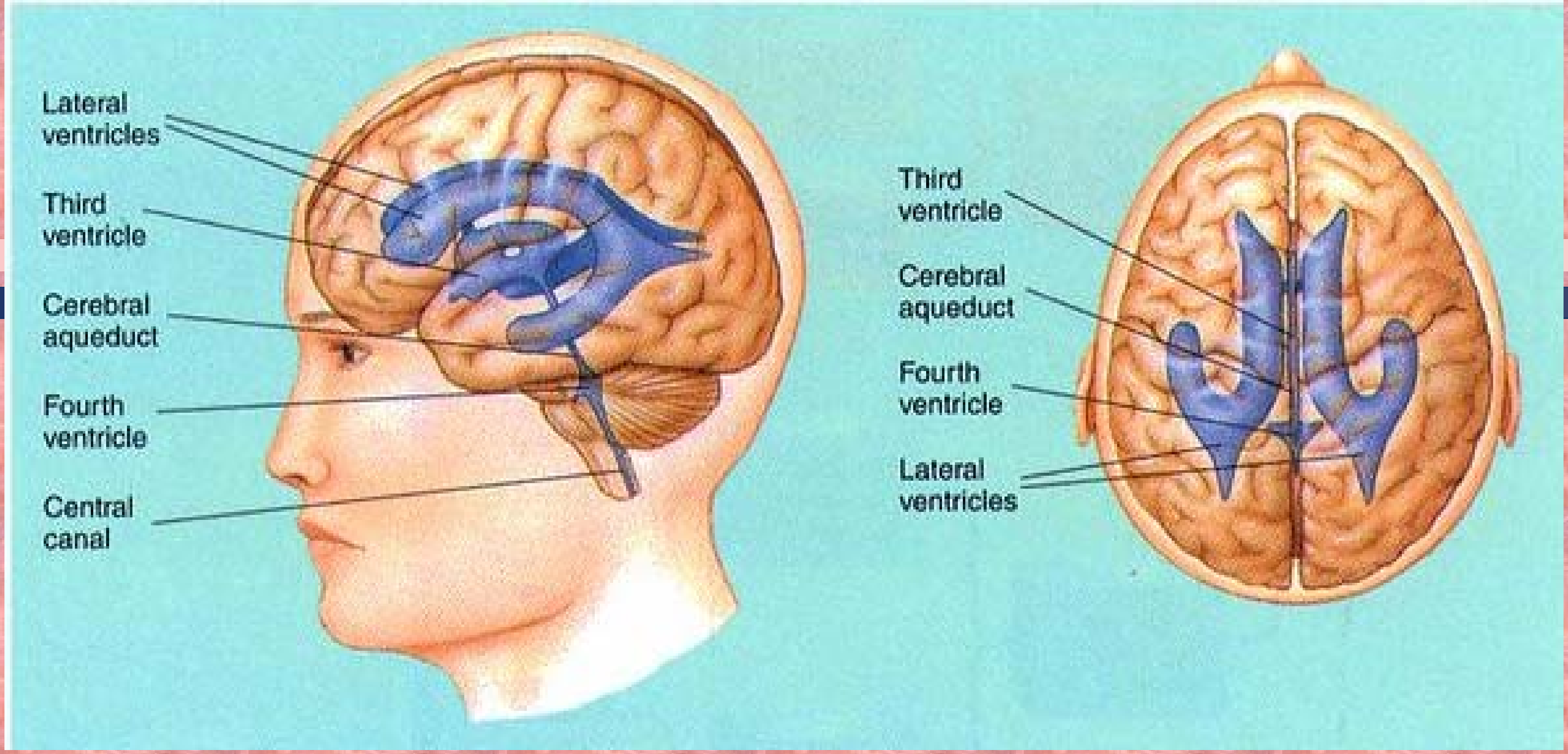


choroid plexus

Cerebrospinal Fluid

- produced by the choroid plexuses of the ventricles
- Aids in maintaining the chemical environment of the CNS and the removal harmful chemical waste.
- provides a protective buoyancy for the brain which effectively makes the weight of the brain 1/30th of its actual weight,

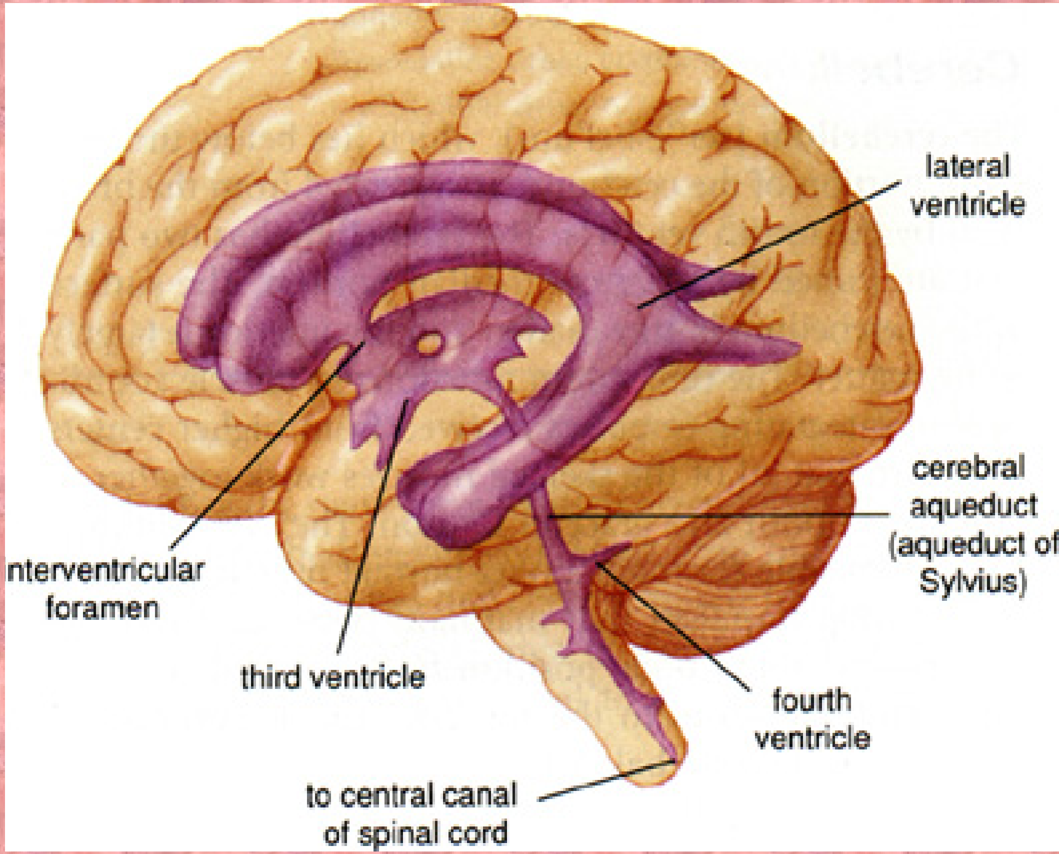




- The brain has four internal chambers called ventricles
  - lateral ventricles- two lateral ventricles, one in each cerebral hemisphere
  - third ventricles- beneath the corpus callosum and surrounded by the thalamus.
  - fourth ventricle- between the hemispheres of the cerebellum.

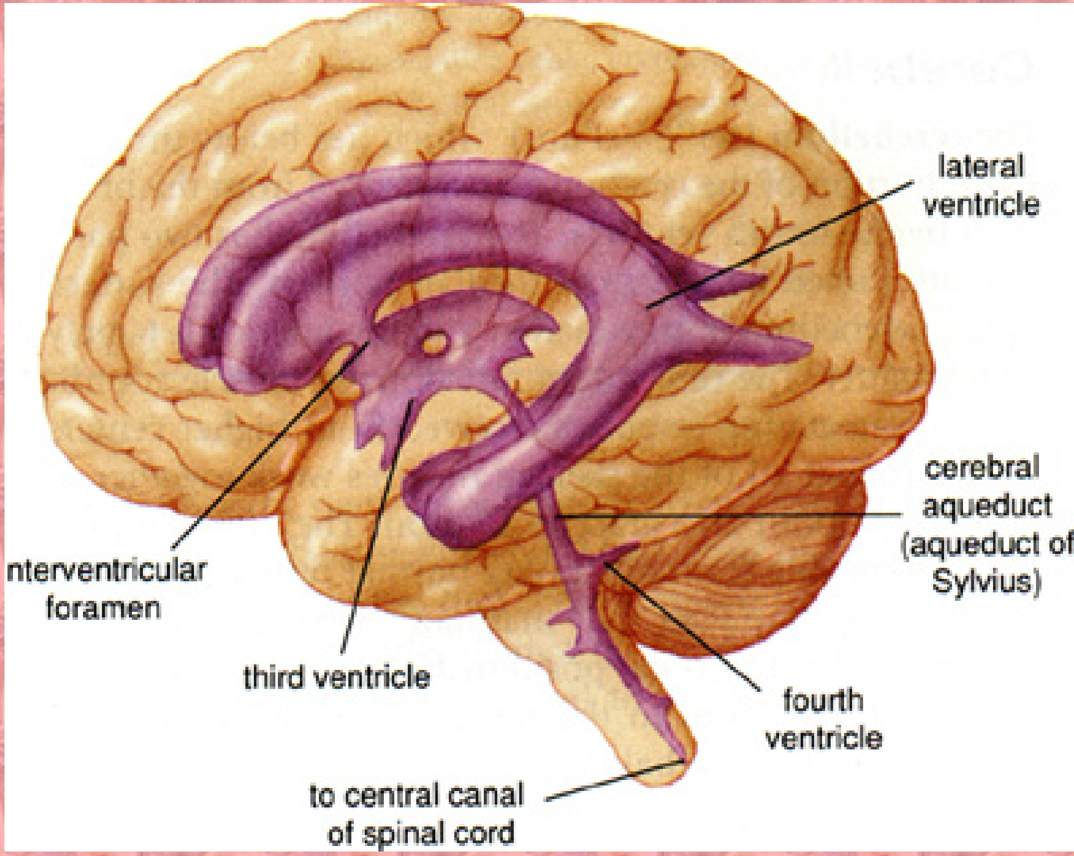
Ventricles

- **interventricular foramen** (Foramen of Monro)- tiny passage that connects lateral ventricles to the third ventricle
- **cerebral aqueduct** (aqueduct of Sylvius)- small canal that passes down the core of the midbrain and leads to the fourth ventricle (a small chamber between the pons and cerebellum



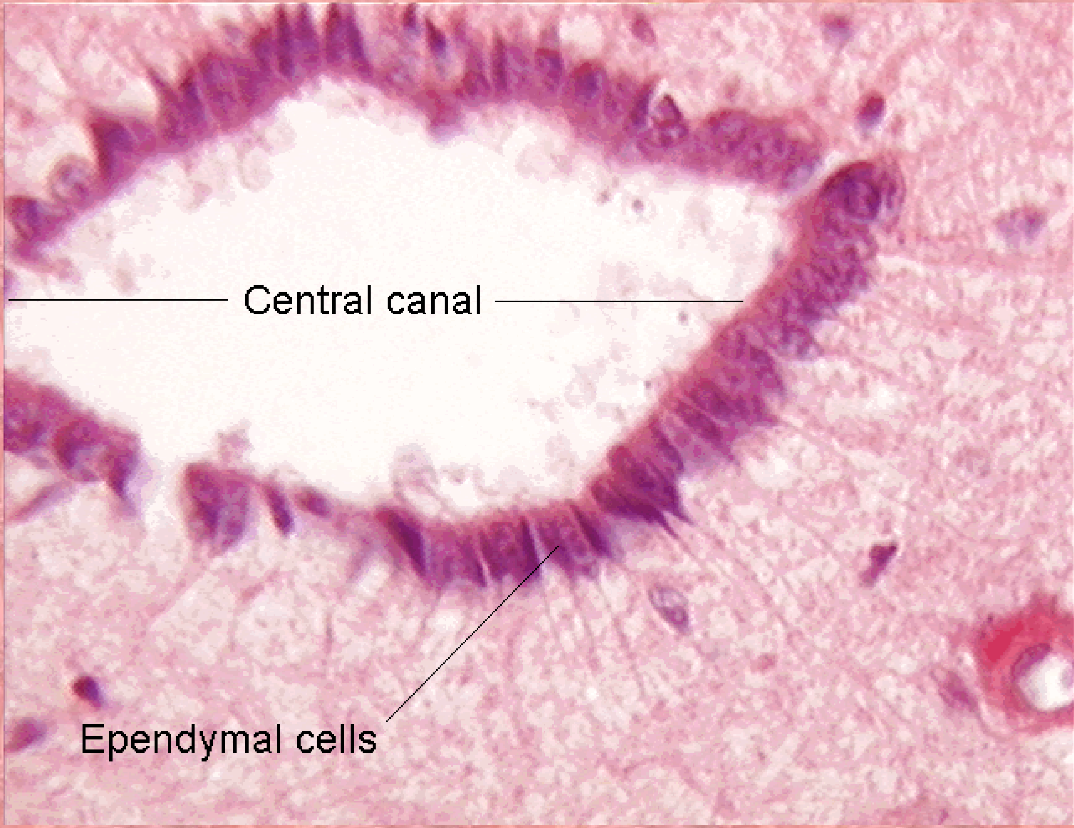
Ventricles

- central canal- extension of the fourth ventricle through the medulla oblongata into the spinal cord.
- Foramina of Luschka- One of the two lateral openings draining the fourth ventricle into the subarachnoid space at the cerebellopontine angle.
- Foramen of Magendie-, medially connects the ventricle with the subarachnoidal space.



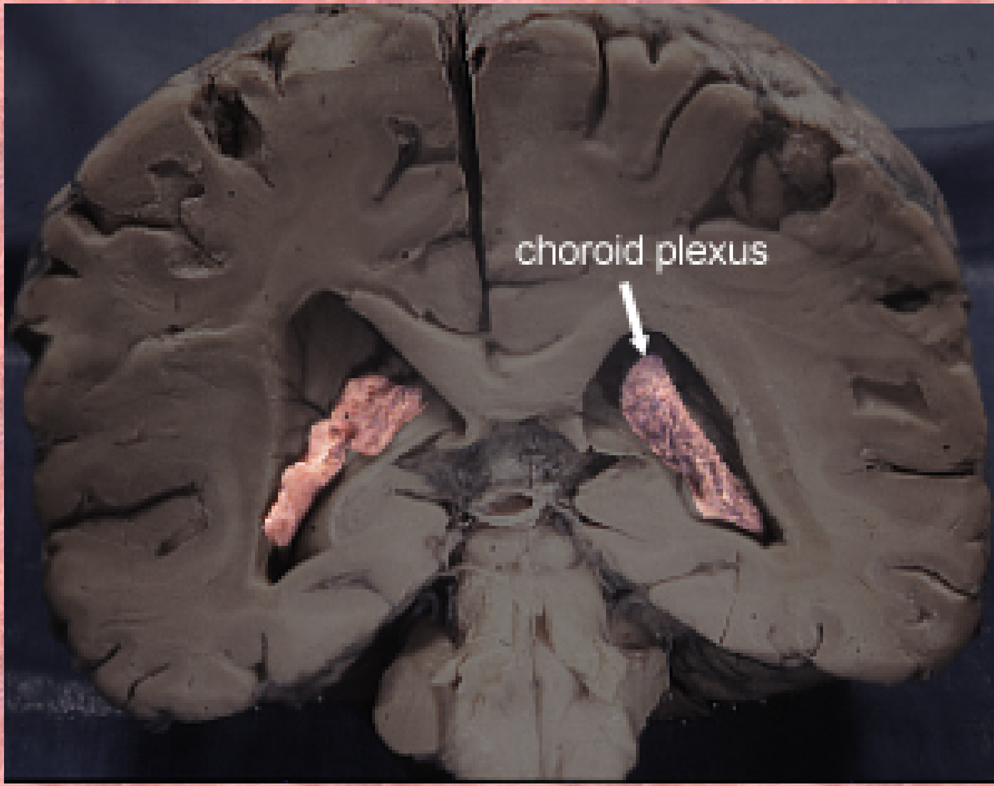
Ependymal Cells

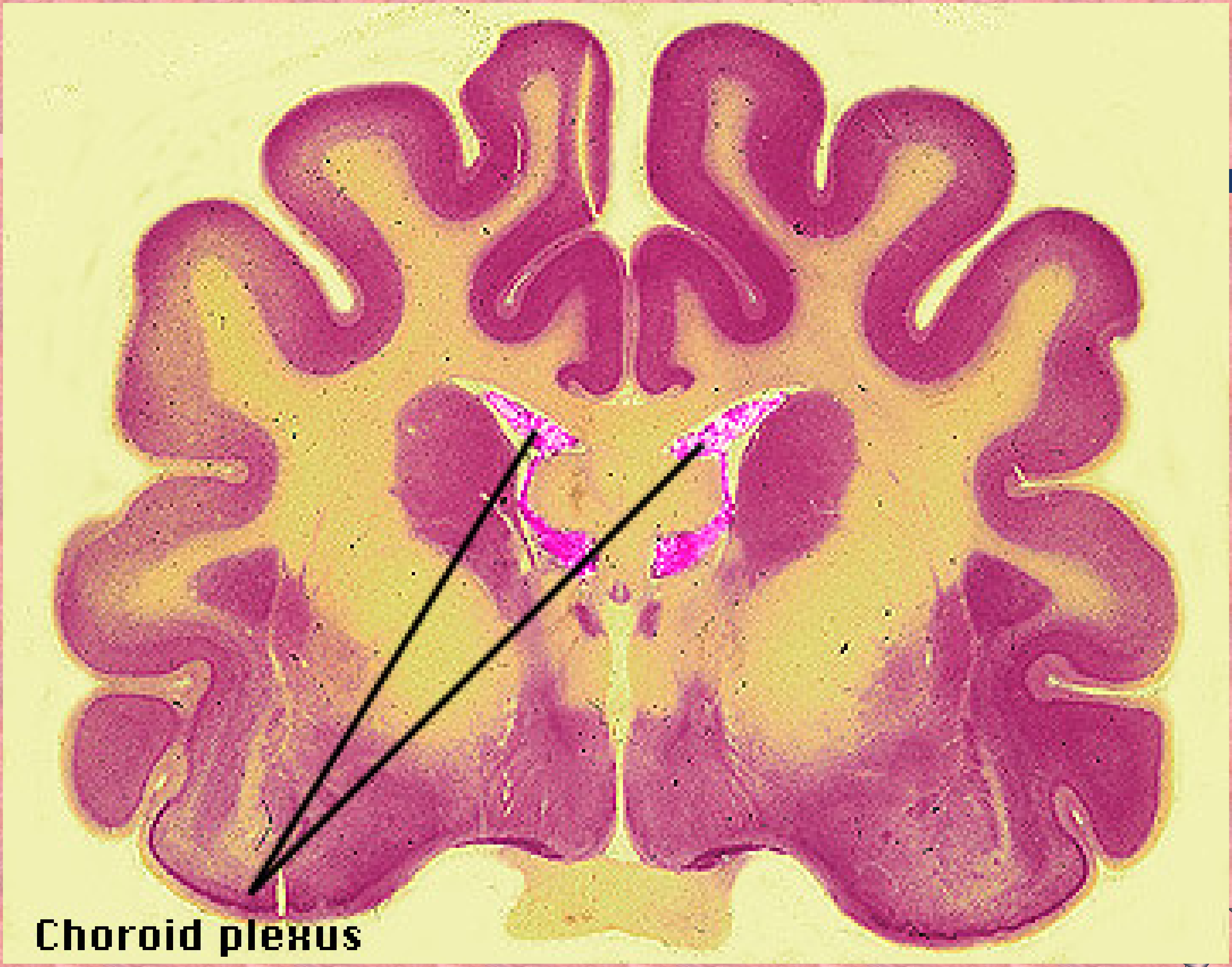
- Ciliated cells that line the brain's ventricles and the spinal cord's central canal and which circulates the spinal fluid inside the brain ventricles and the connecting central canal of the spinal cord.

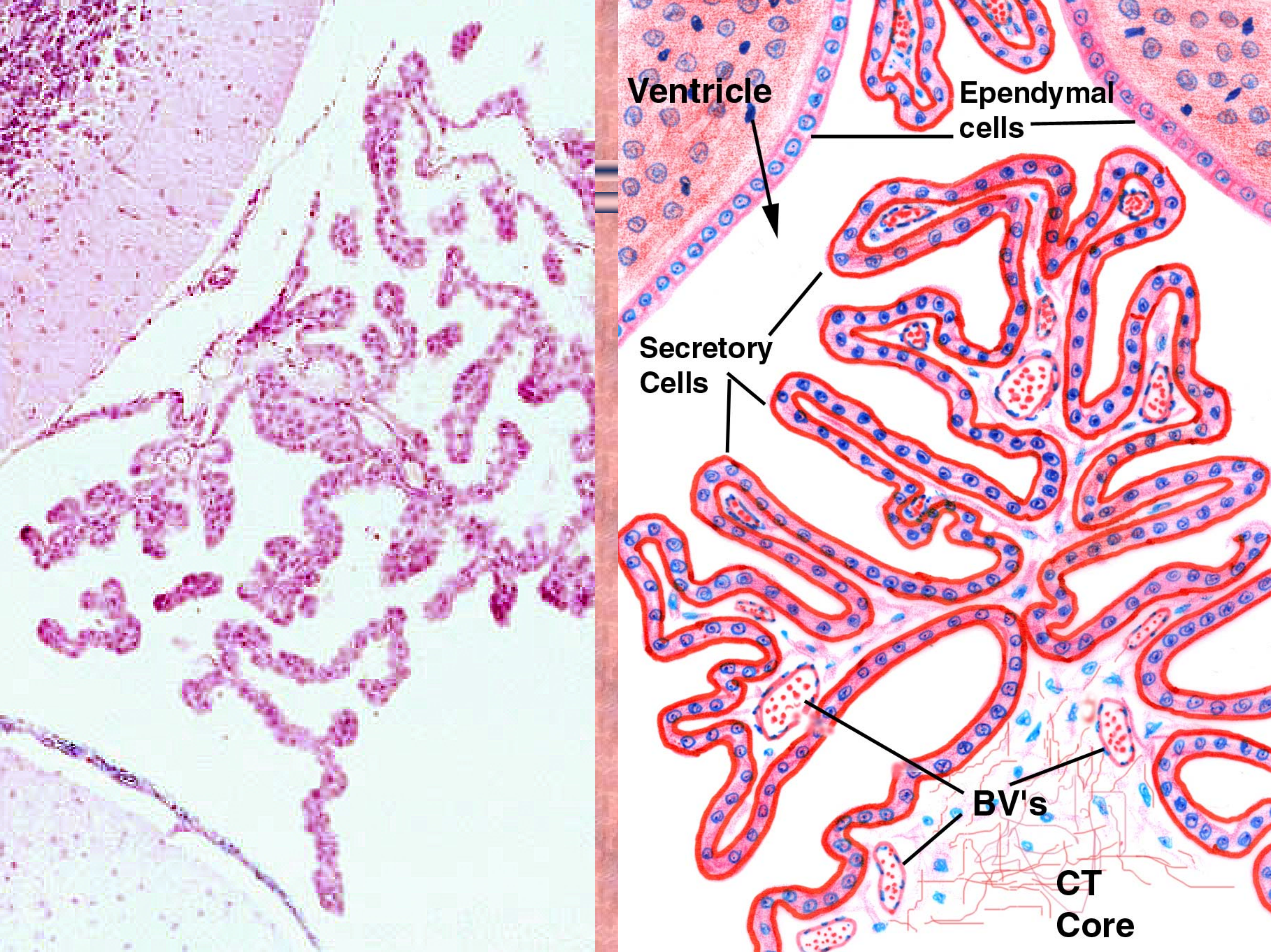


Choroid Plexus

- Found on the walls or roof of each of the four ventricles.
- Formed by an invagintion of the vascular pia mater (the tela choroidea)
- The epithelium that lines the choroid plexus is classified as simple cuboidal.
- The cells will exhibit cilia and microvilli at their free surface.
- This epithelial lining continues into the spinal cord and forms the ependyma.
- Using materials brought in the circulation, the cells of the choroid plexus synthesize the components of the cerebrospinal fluid and secrete it into the lumen of the ventricles.



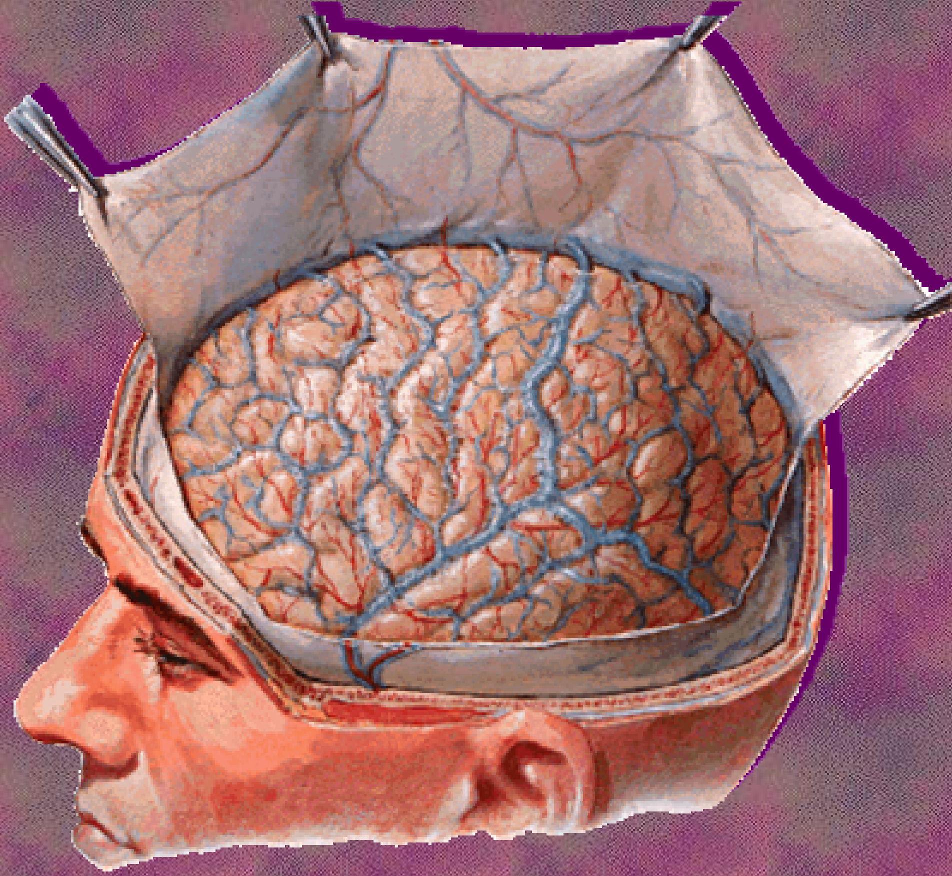

Choroid plexus

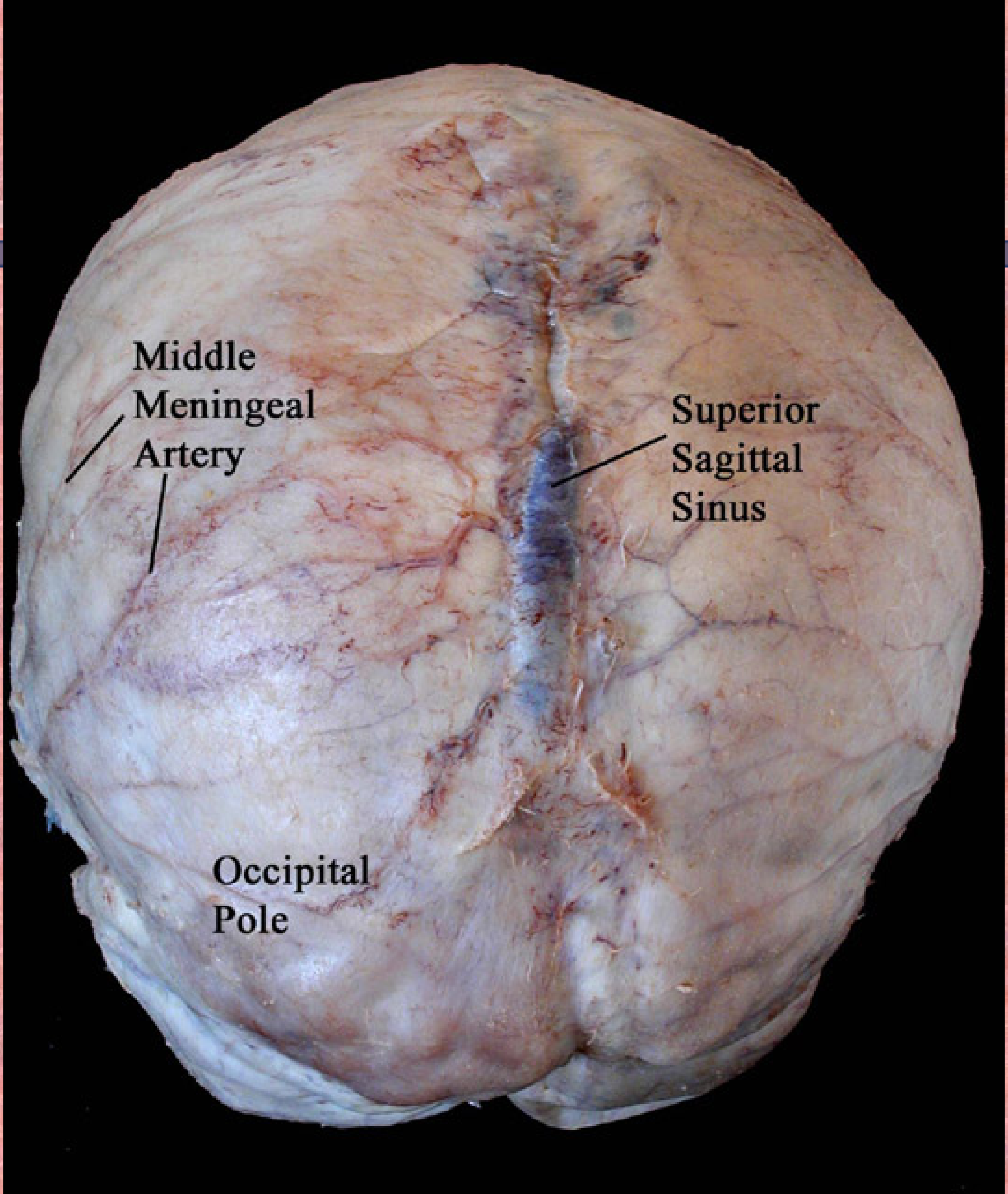


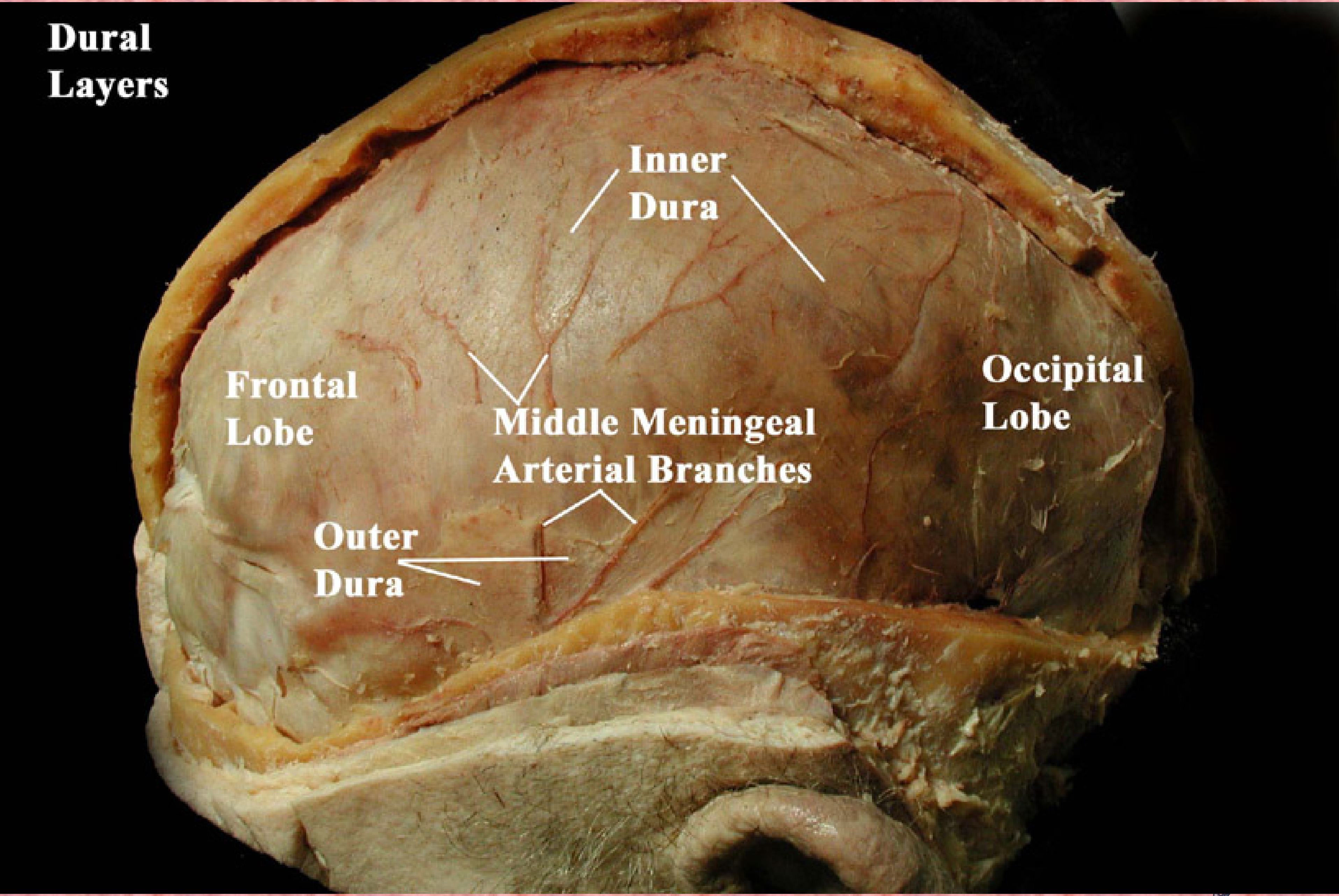
Ventricle
Ependymal cells
Secretory Cells
BV's
CT Core

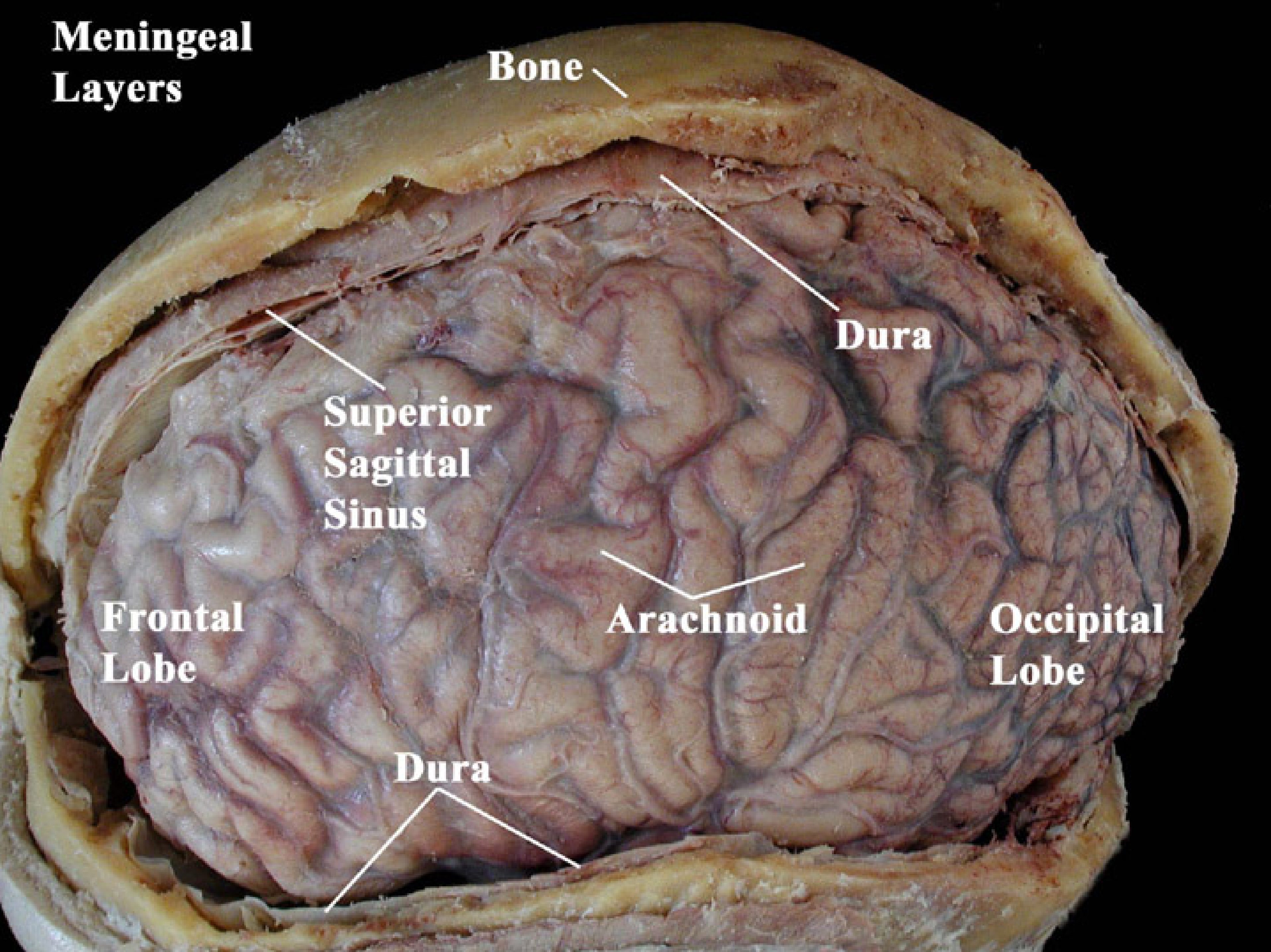
Three Layers of Meninges

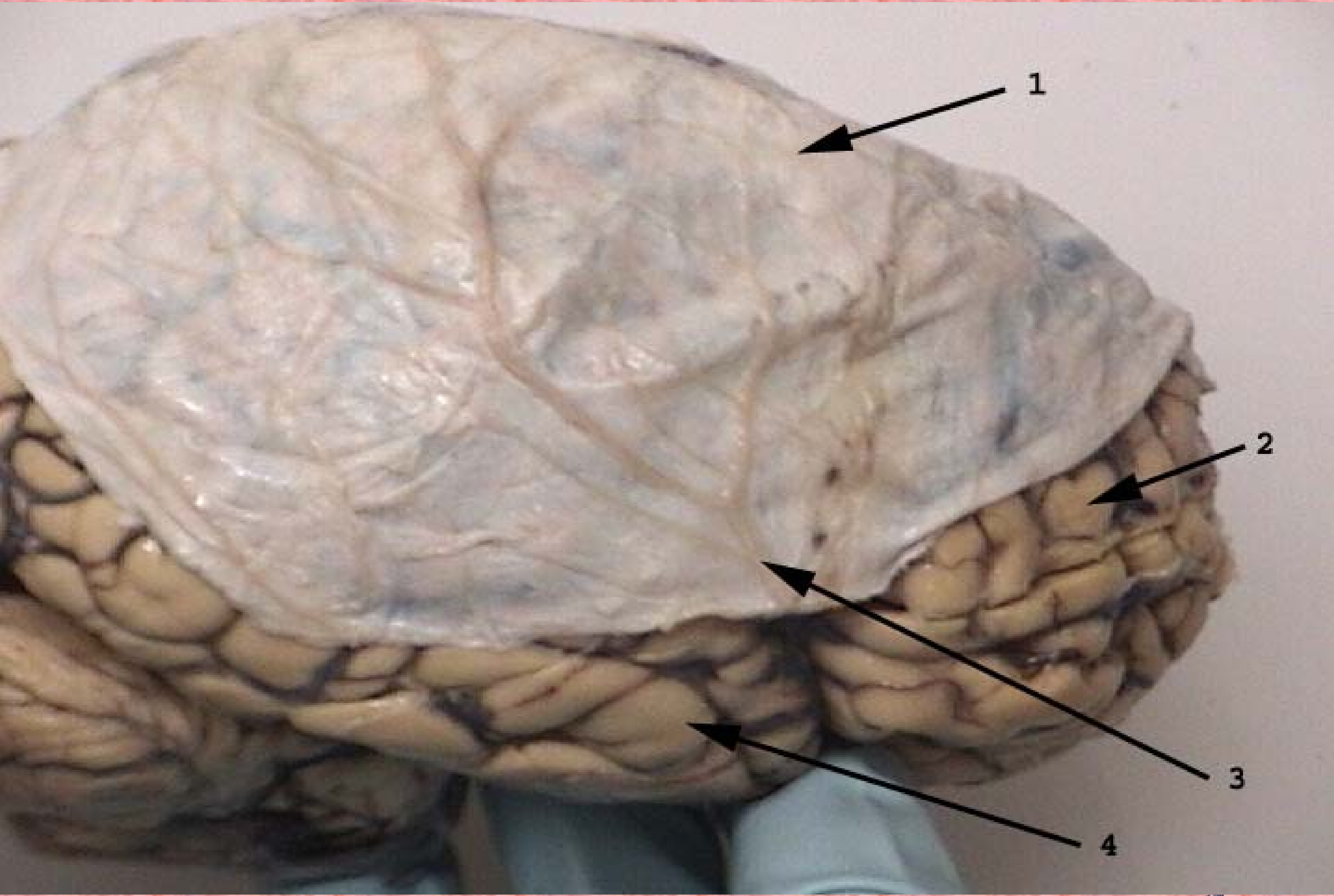
- **Dura Mater**
  - Most superficial
  - Tough, double-layered membrane
  - Outer layer is fused to skull
  - In some areas the layers separate to enclose **dural sinuses**
  - Extends inward in some areas forming **septa** to anchor the brain to the skull

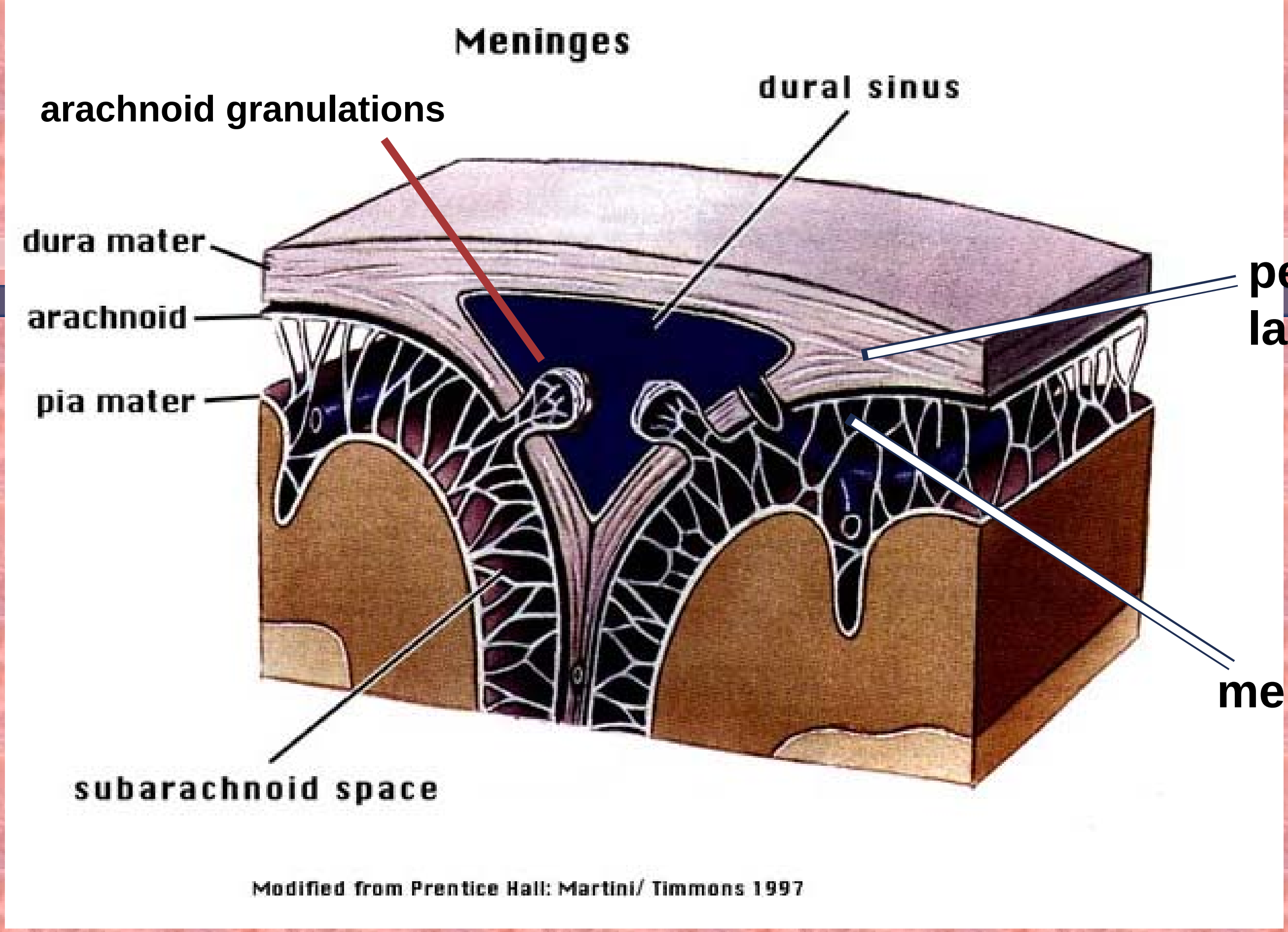



Middle
Meningeal
Artery
Superior
Sagittal
Sinus
Occipital
Pole

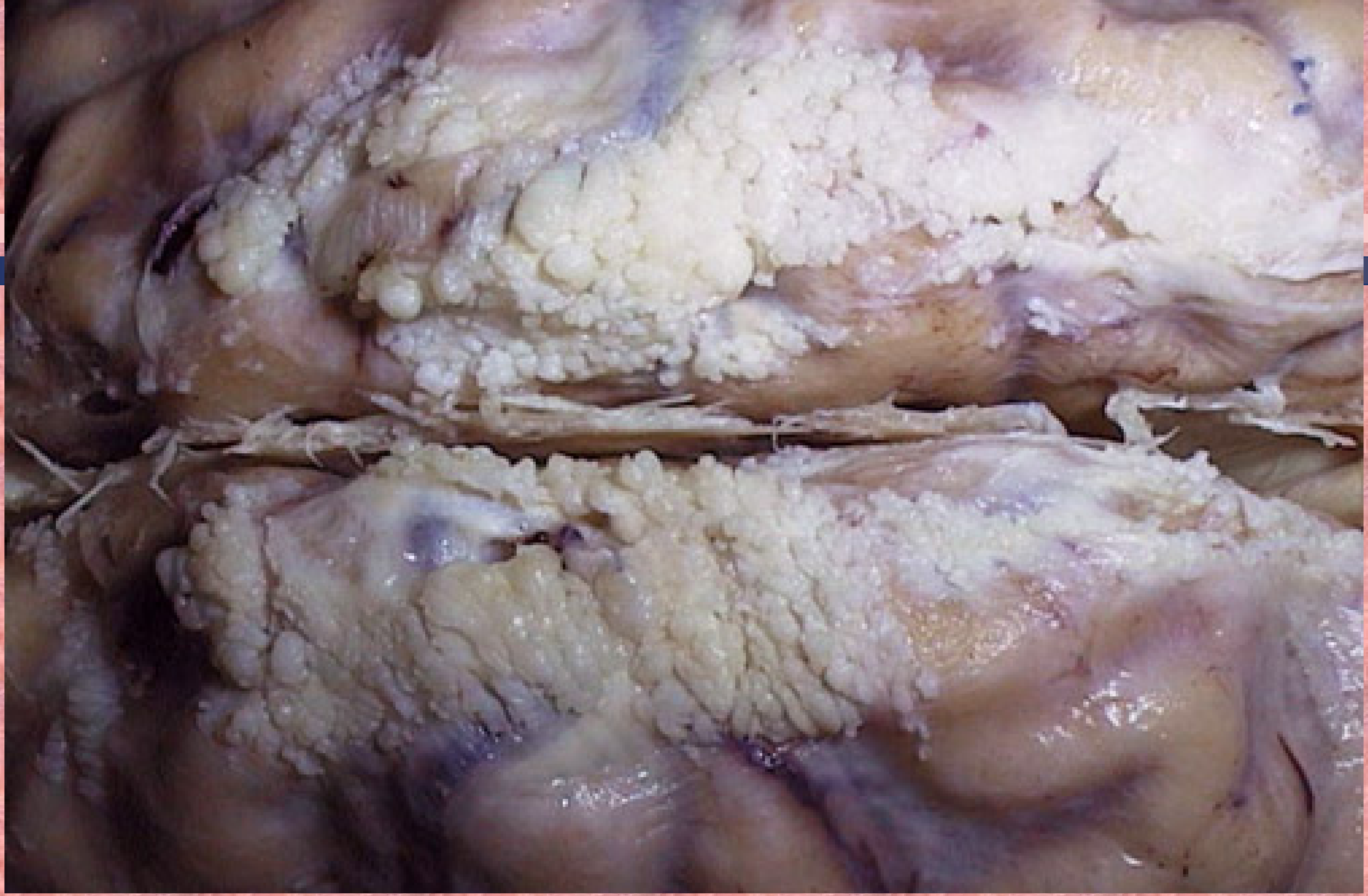

Dural
Layers
Inner
Dura
Frontal
Lobe
Middle Meningeal
Arterial Branches
Occipital
Lobe
Outer
Dura


Meningeal Layers
Bone
Dura
Superior Sagittal Sinus
Frontal Lobe
Arachnoid
Occipital Lobe
Dura


1
2
3
4



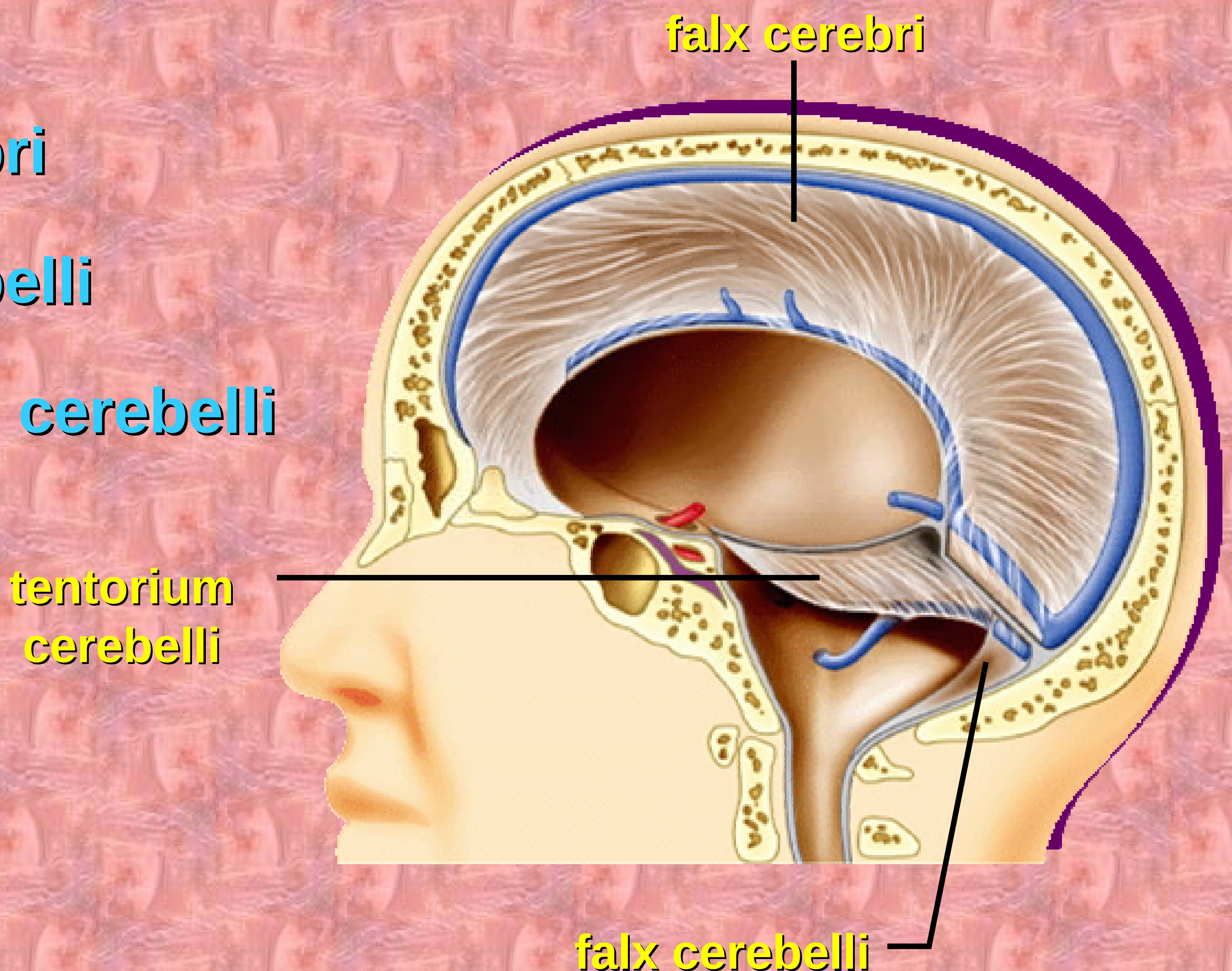
- the dura in the cranial cavity consist of two layer
  - periosteal layer- equivalent to the periosteum of the cranial bone, lies close to the bone with no epidural space
  - meningial layer- continues into the vertebral column
- the two layers are separated in places by the dural sinuses (spaces that collect blood that has circulated through the brain)

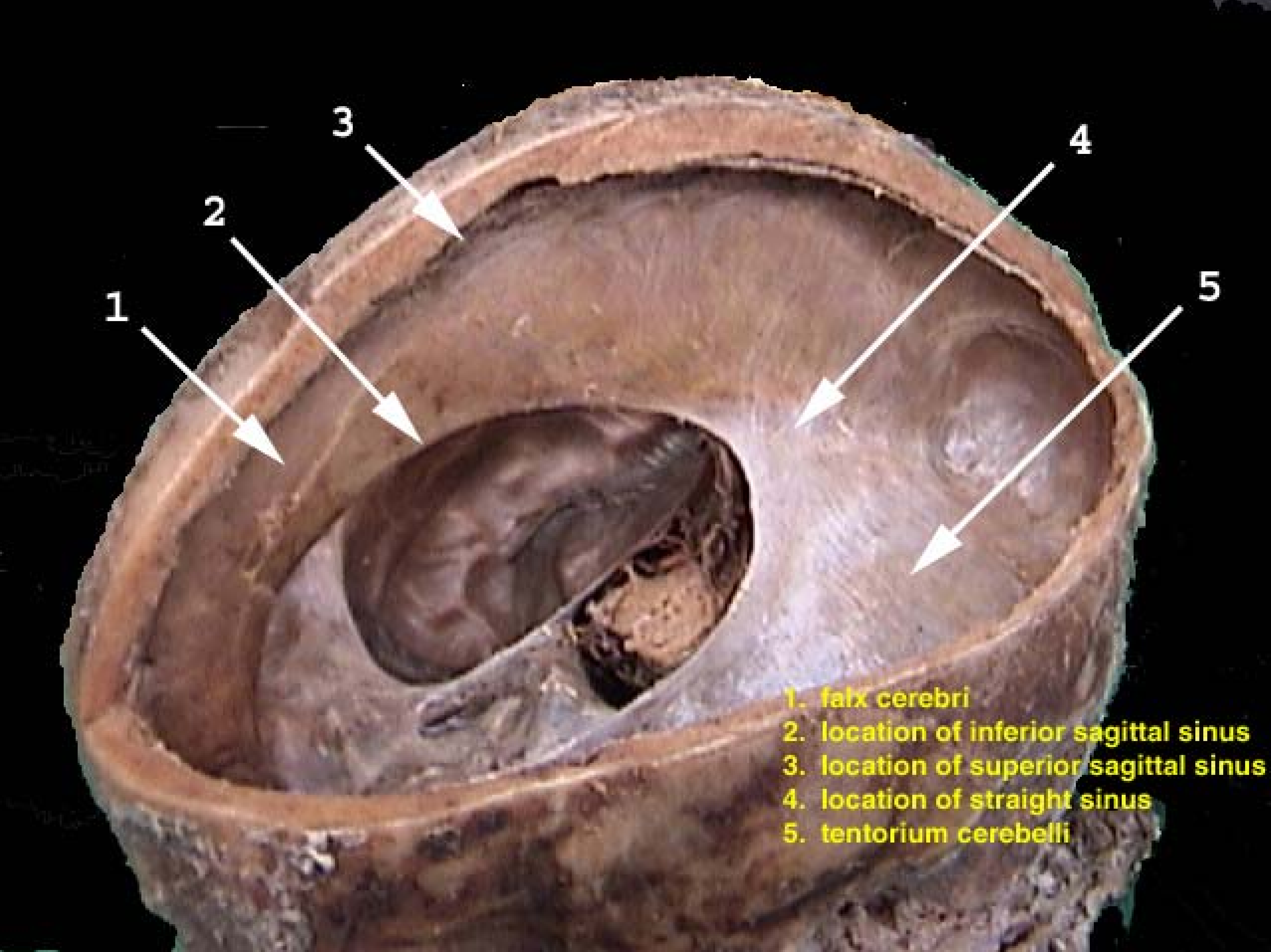


- The nodular white excresences seen here over the cerebral hemispheres at the vertex on both sides of the central fissure with falx cerebri of the brain are the <u>arachnoid granulations</u>.

Dural Septa

- **Dural Septa**
  - **Falx cerebri**
  - **Falx cerebelli**
  - **Tentorium cerebelli**




3
2
1
4
5
1. falx cerebri
2. location of inferior sagittal sinus
3. location of superior sagittal sinus
4. location of straight sinus
5. tentorium cerebelli

Flax Cerebri

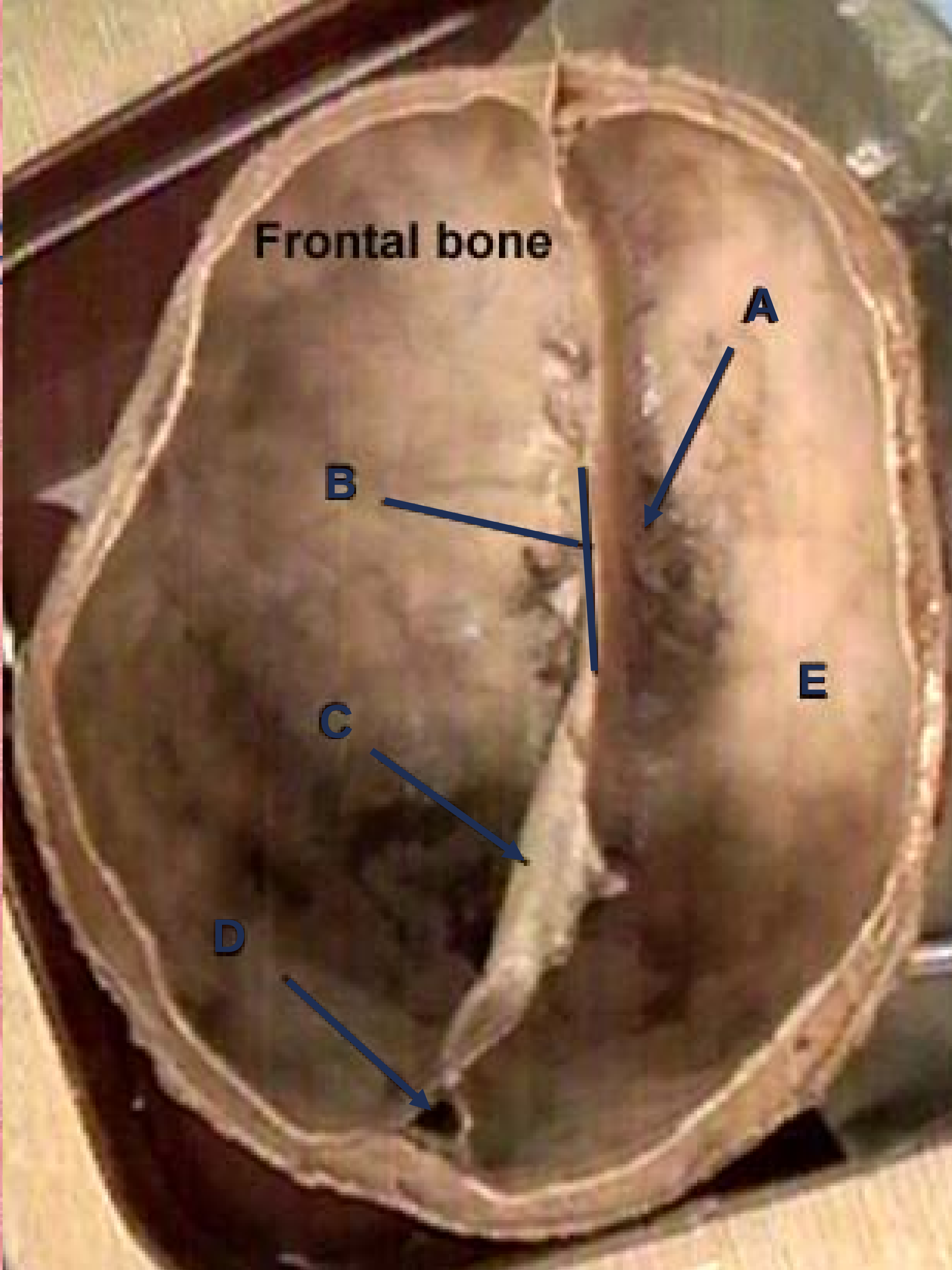
A. Superior sagittal sinus

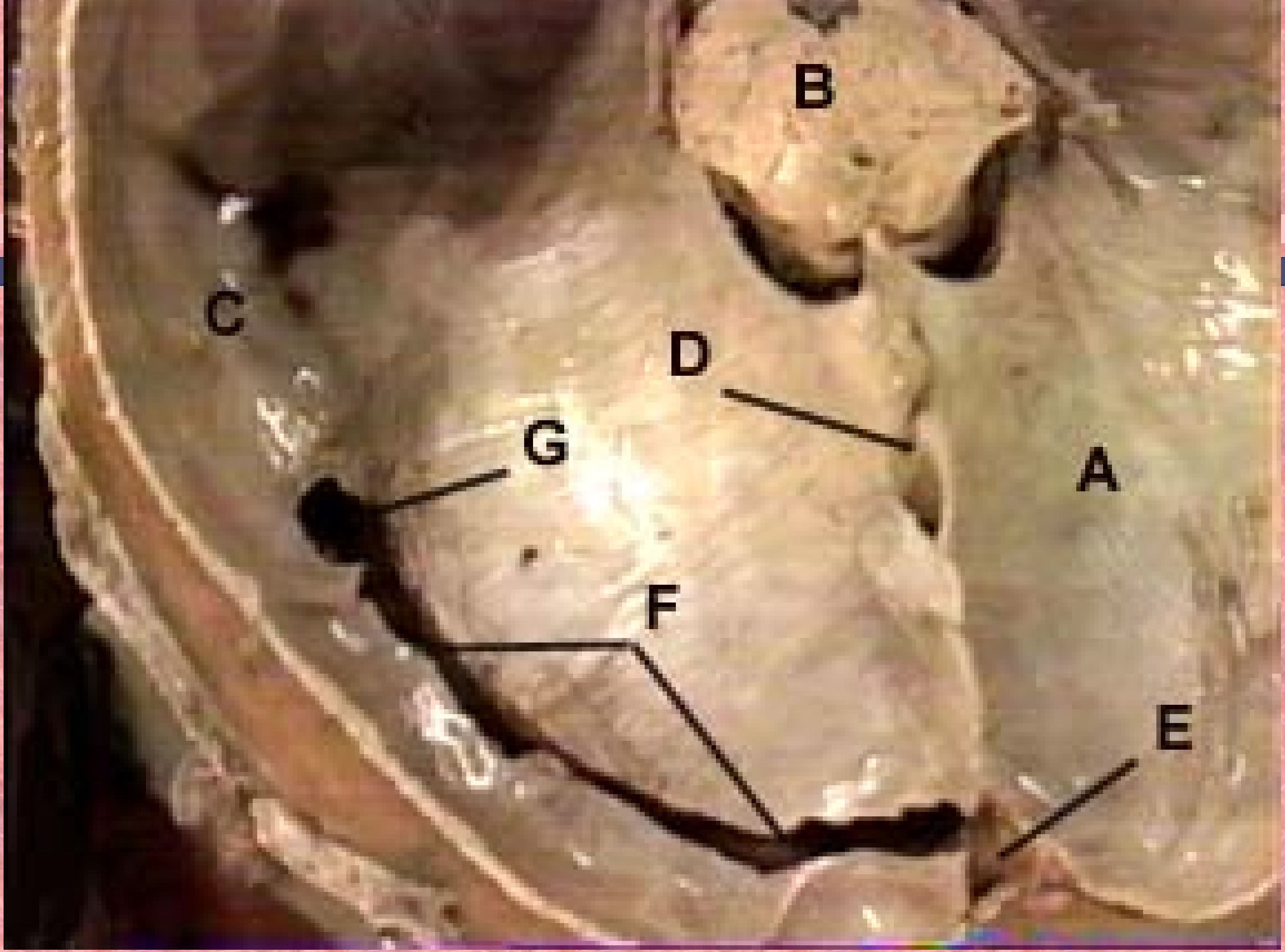
B. Inferior sagittal sinus

C. Falx cerebri (dual fold)

D. Confluence of sinuses

E. Dura mater (meningeal layer)

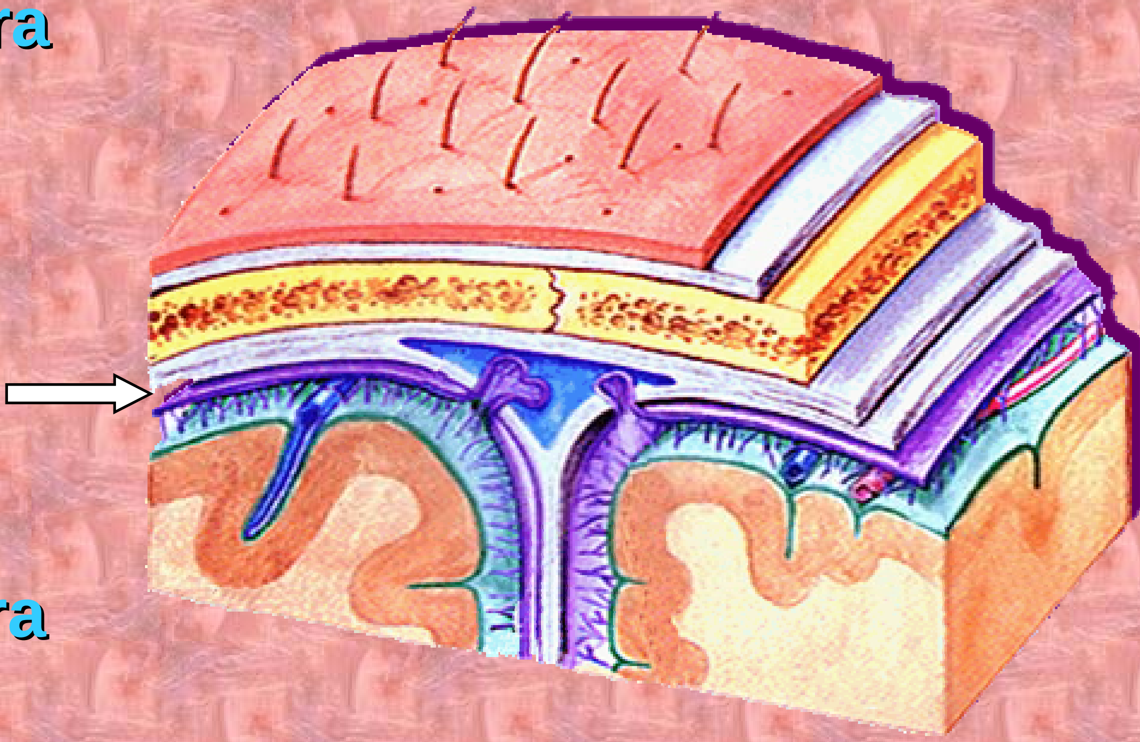




A. Tentorium cerebelli B. Midbrain tegmentum C. Temporal bone(Petrous part)
D. Inferior sagittal sinus E. Confluence of sinuses F. Transverse sinus
G. Sigmoid sinus
.

Dural Spaces

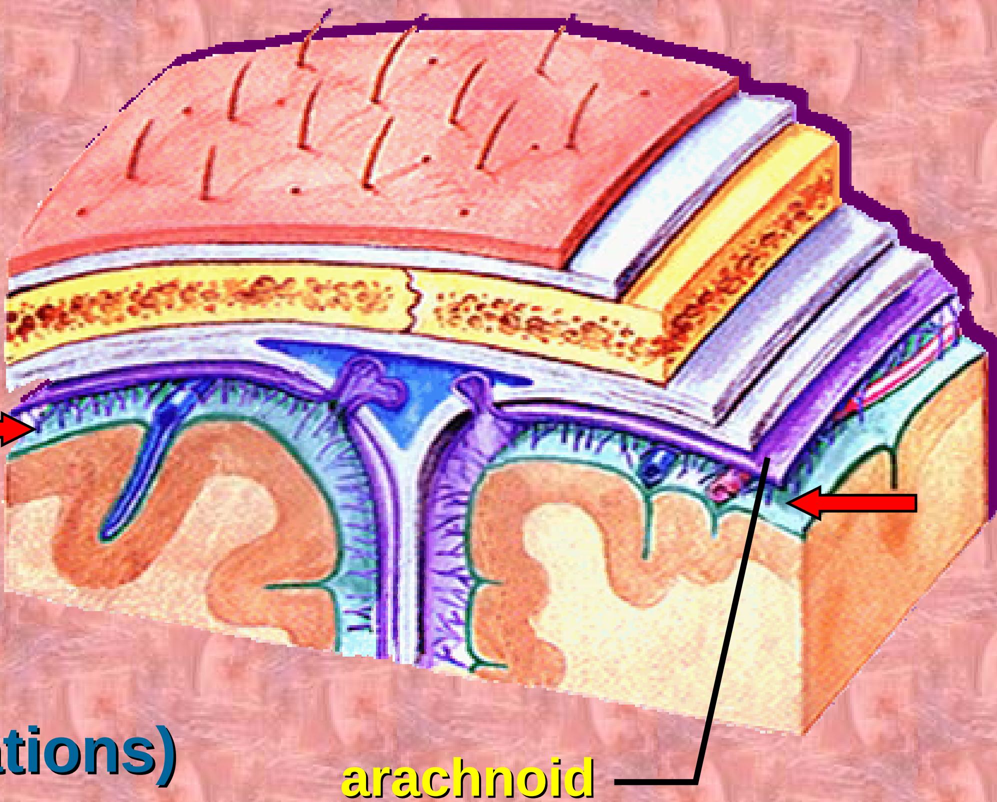
- **Subdural space**
  - **Space below dura and above arachnoid layer below**



- **Epidural space**
  - **Space between bone and the dura (above the dura)**
  - **Not present in the skull**

Three Layers of Meninges

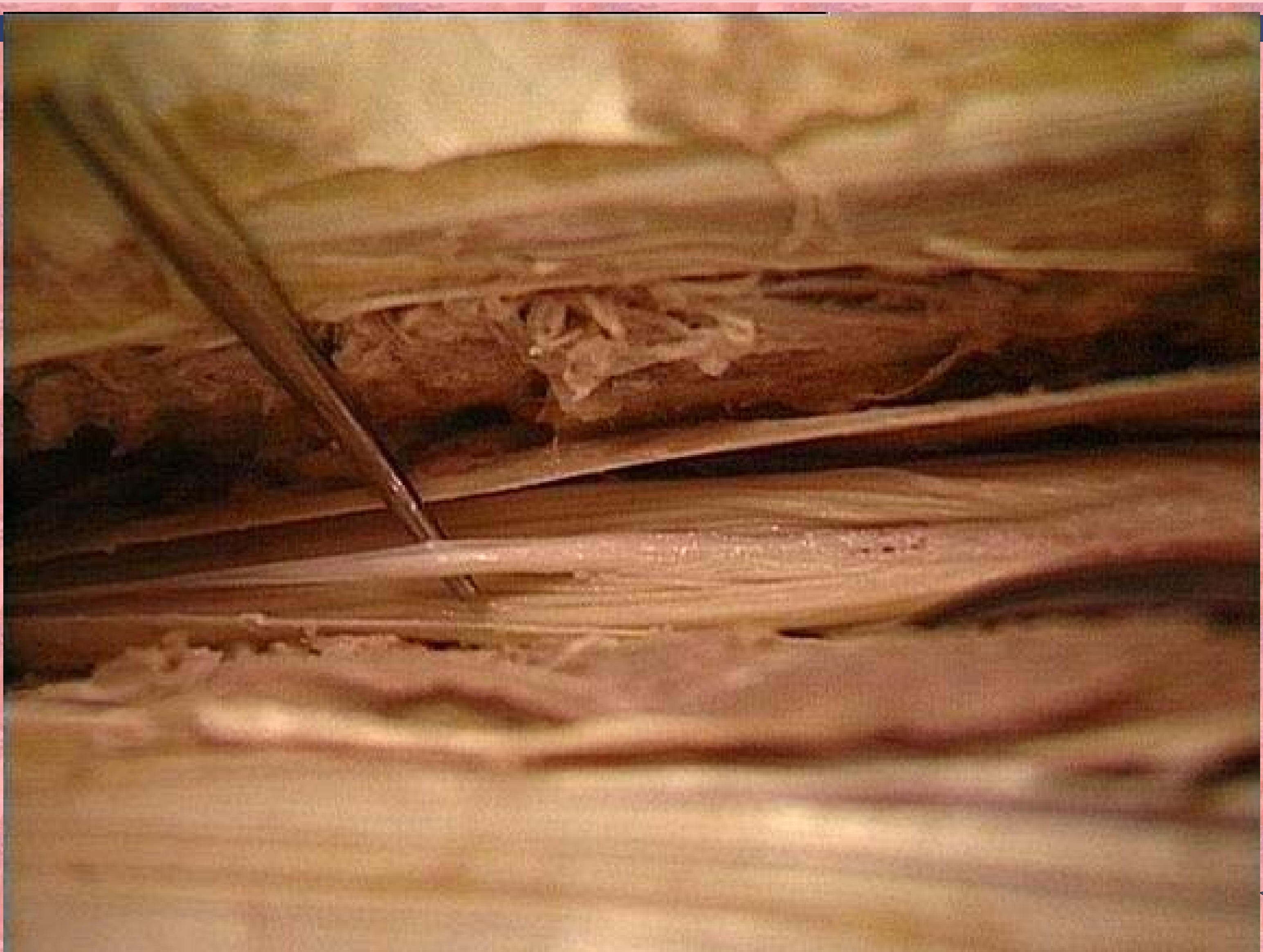
- **Arachnoid (Mater) Layer**
  - Deep to dura
  - Web-like extensions down to pia mater below
  - **Subarachnoid space**
    - Space below arachnoid membrane
    - Filled with CSF
    - Numerous blood vessels
  - **Arachnoid villi (granulations)**
    - Drain CSF into dural sinuses



Three Layers of Meninges

- **Pia Mater**
  - **Innermost layer**
  - **Adheres to brain and spinal cord**
  - **Follows folds of brain**
  - **Very vascular**
  - **Small extension of pia called the filum terminale fastens the spinal cord down to the coccyx bone**

Cauda Equina and Terminal Filum

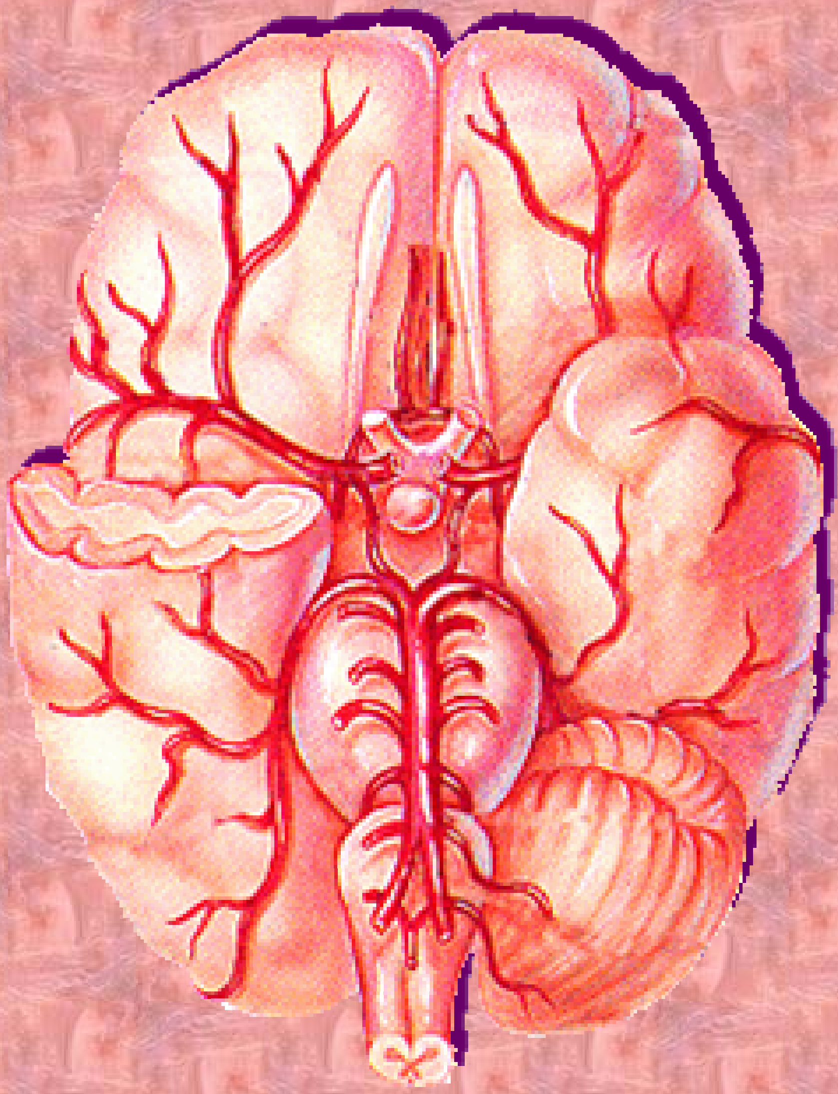


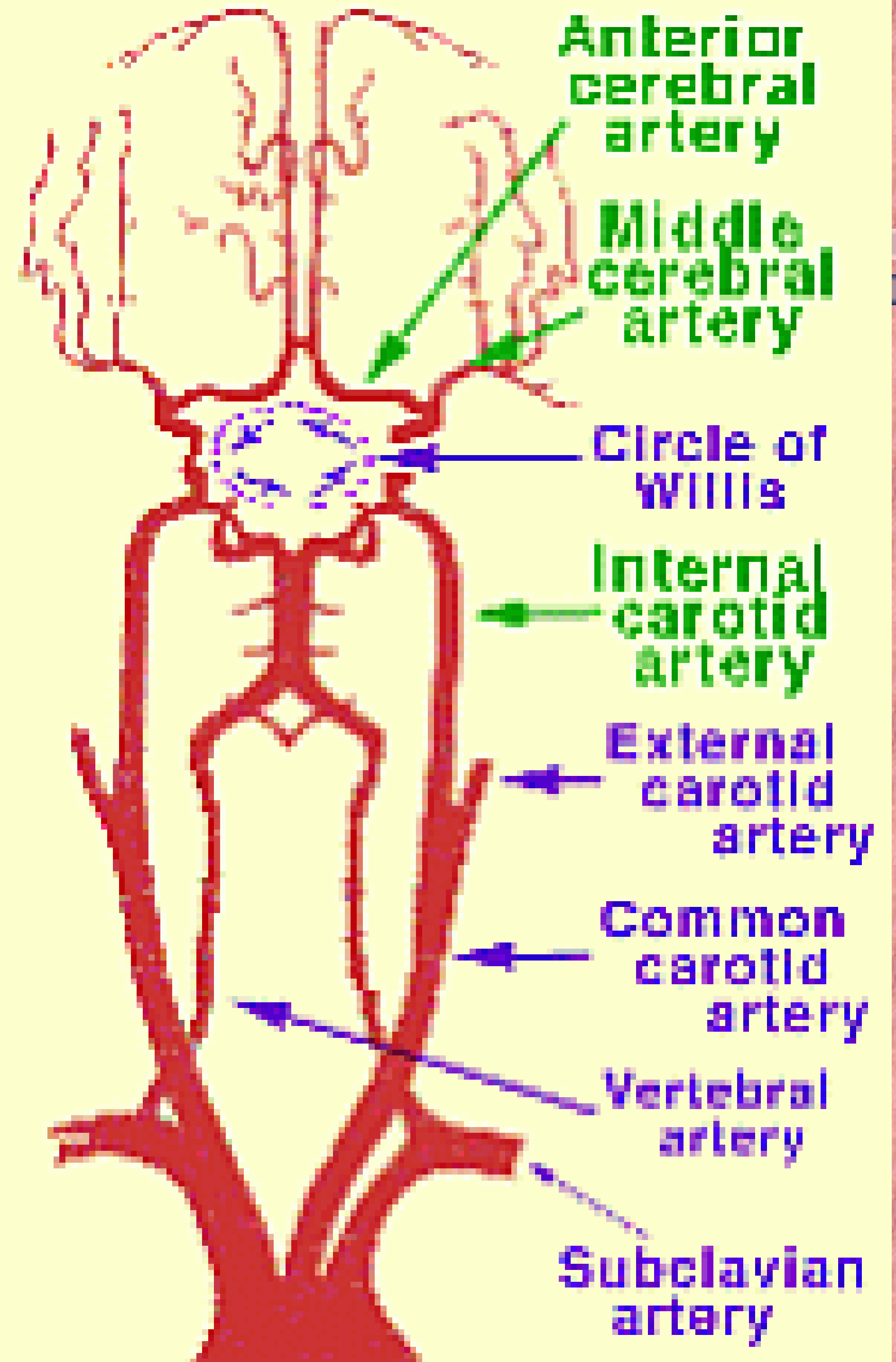
Cauda equina with conus medularis and terminal filum

Cauda Equina

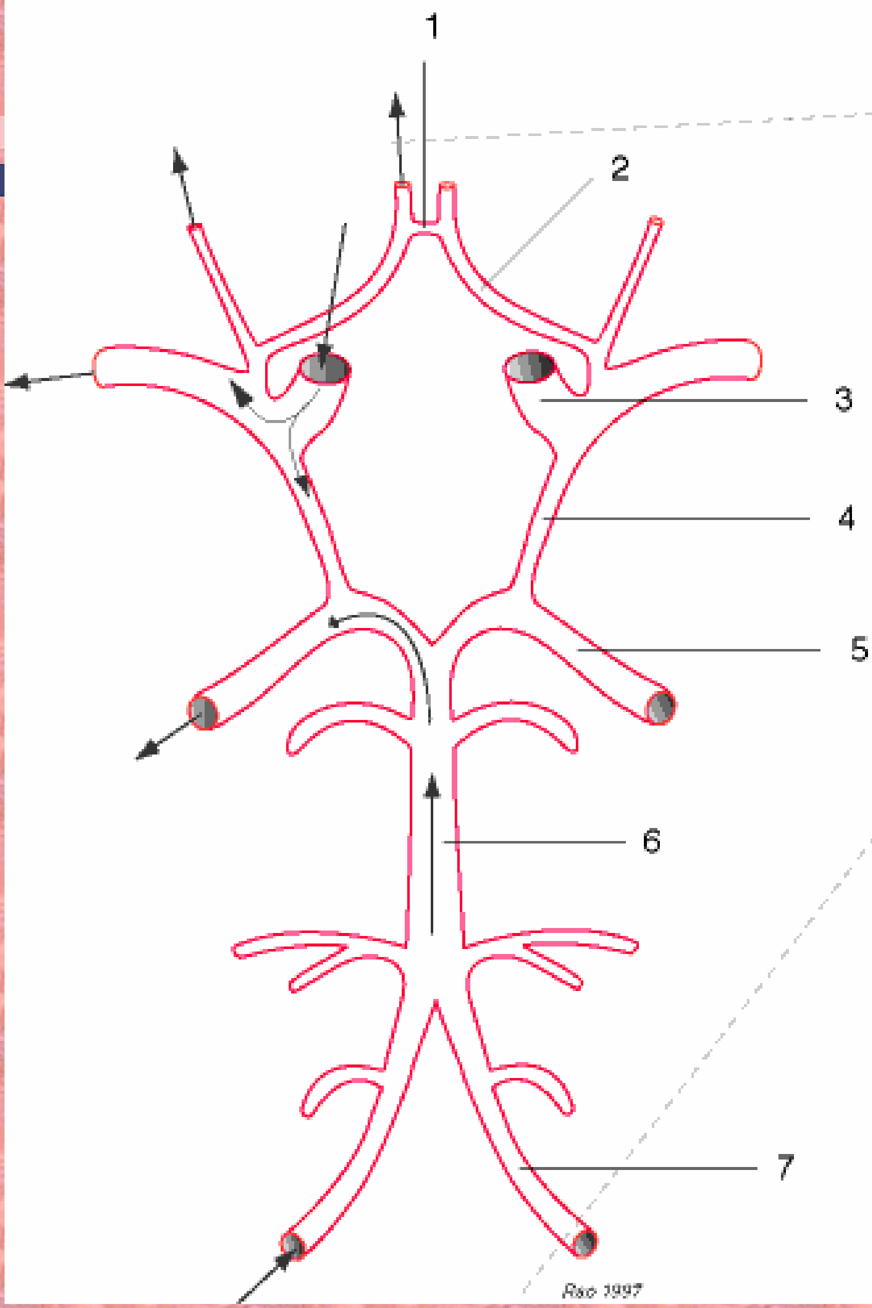
Blood Supply To The Brain

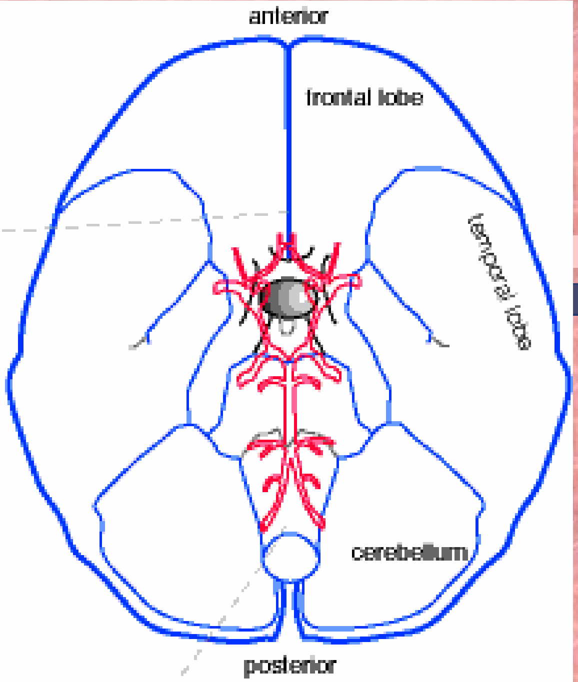
- **Circle of Willis**
  - **Circular network of blood vessels supplying the brain**
  - **2 vertebral, 2 internal carotid arteries contribute**
  - **Many anastamoses help curtail inadequate blood supply to the brain**




Anterior cerebral artery
Middle cerebral artery
Circle of Willis
Internal carotid artery
External carotid artery
Common carotid artery
Vertebral artery
Subclavian artery

The Arterial Circle of Willis

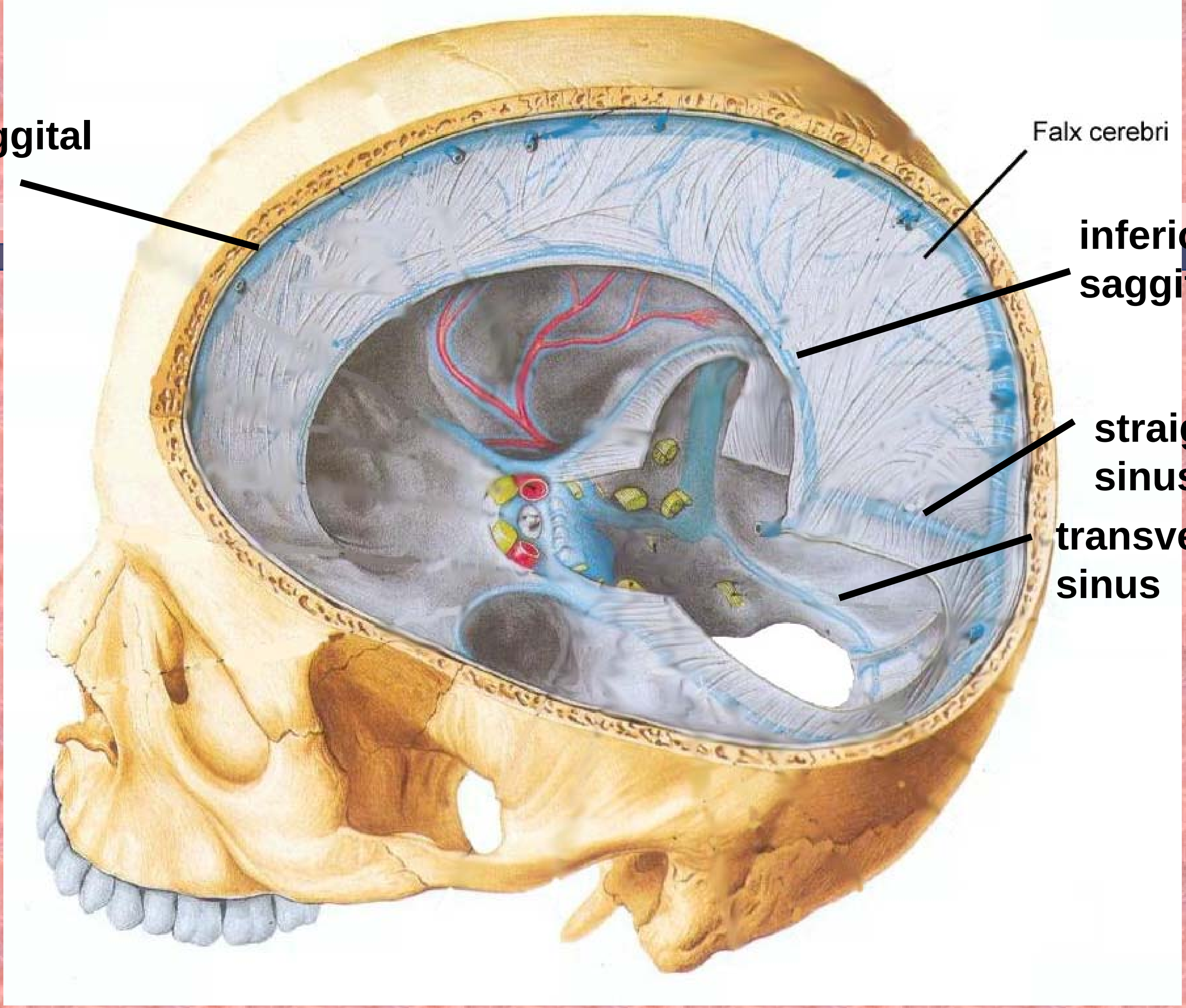




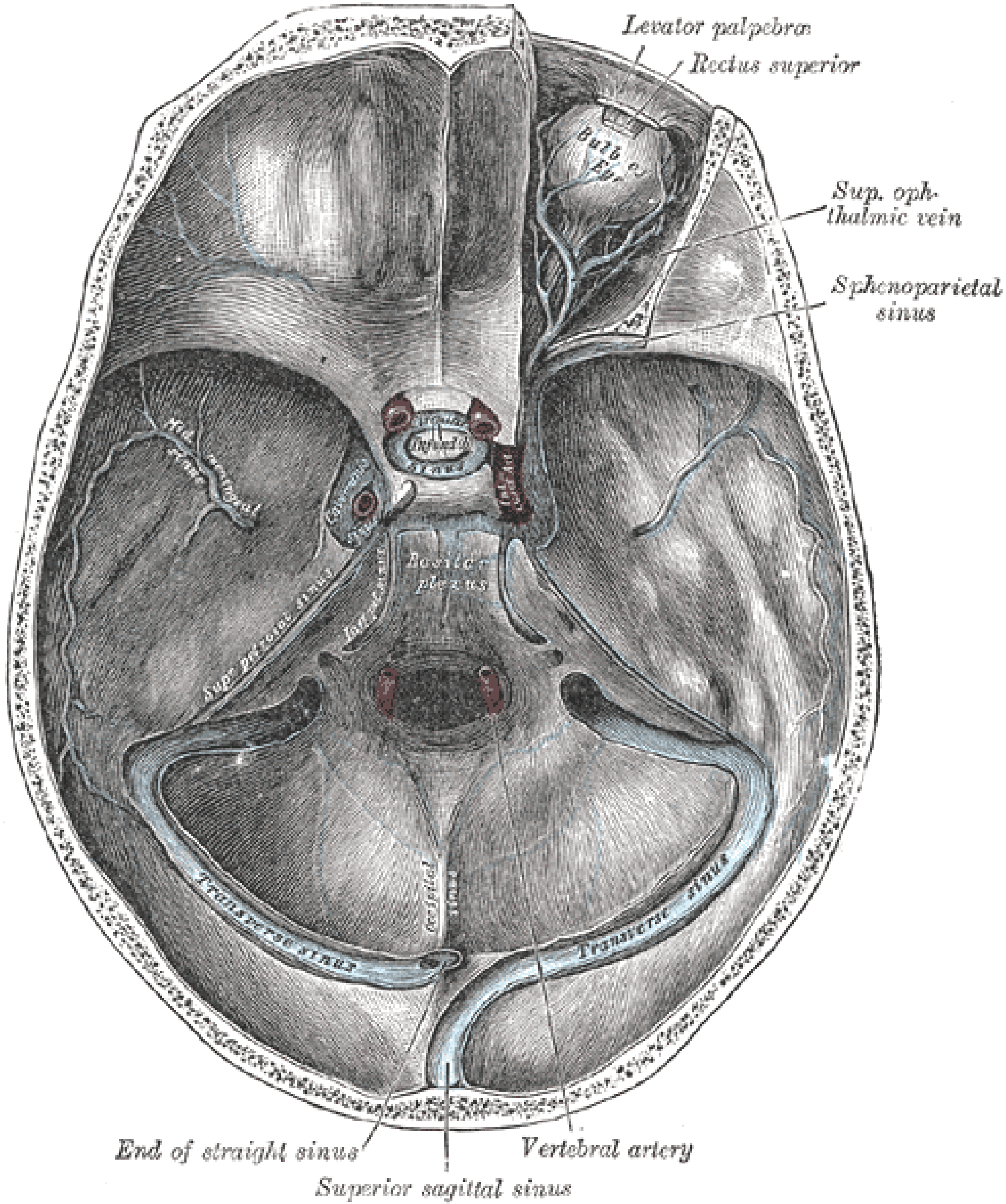
Inferior view of the brain

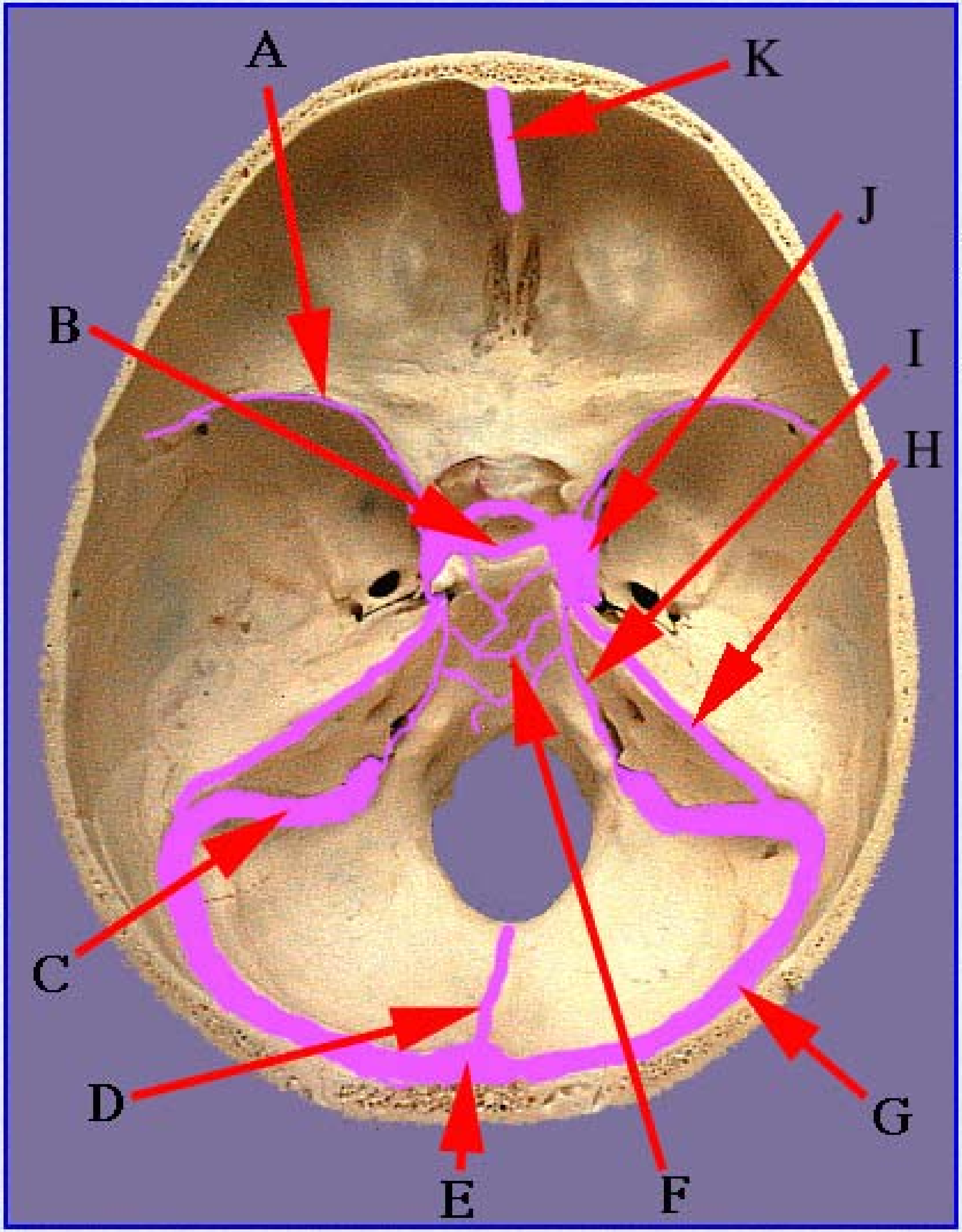
Arteries of the Circle of Willis*

1. Anterior communicating*
2. Anterior cerebral*
3. Carotid
4. Posterior communicating*
5. Posterior cerebral*
6. Basilar
7. Vertebral



- The separations of the two layers of the dura mater create the dural venous sinuses. The venous sinuses receive the blood from the veins draining the brain, and this blood flows from the venous sinuses to the internal jugular veins. The walls of the sinuses are line by endothelium.


Levator palpebræ
Rectus superior
Sup. oph-
thalmic vein
Sphenoparietal
sinus
Basilar
plexus
Transverse sinus
Transverse sinus
End of straight sinus
Vertebral artery
Superior sagittal sinus



J. Cavernous

K. Superior Sagittal

Dural Venous Sinuses.

A. Sphenoparietal

B. Intercavernous

C. Sigmoid

D. Occipital

E. Confluence

F. Basilar

G. Transverse

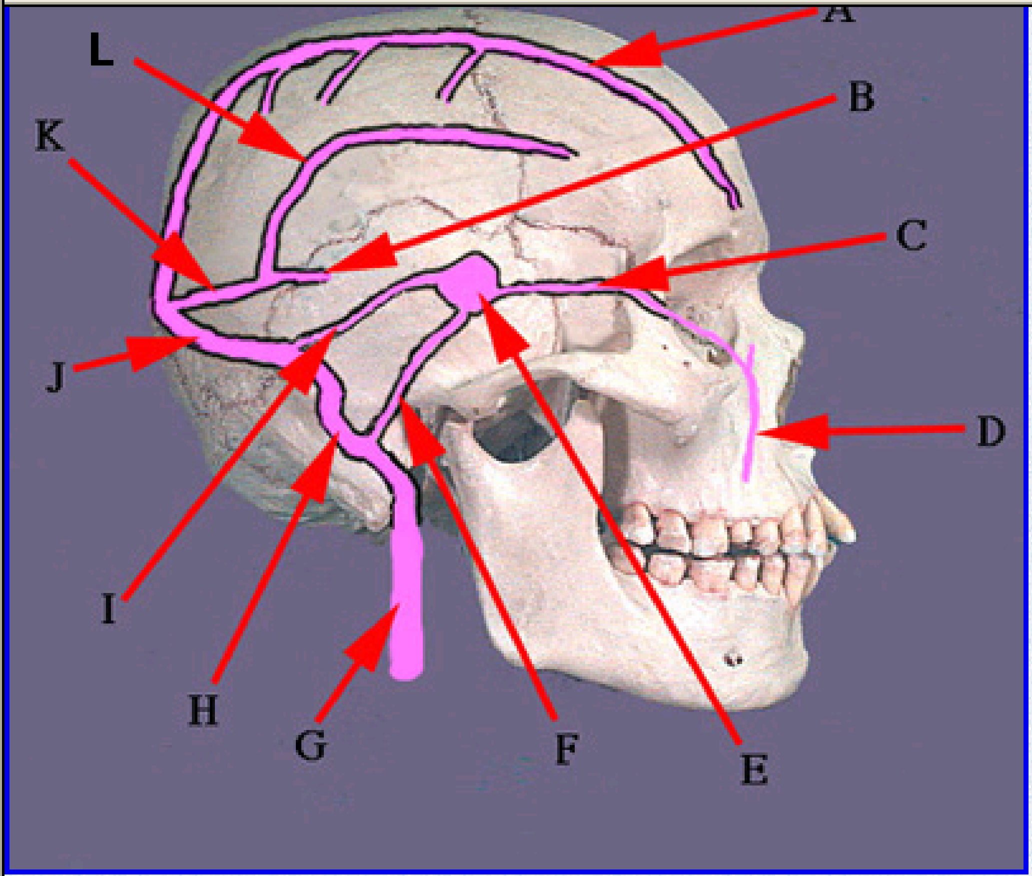
H. Superior Petrosal

I. Inferior Petrosal

J. Cavernous

K. Superior Sagittal

The Dural Venous Sinuses



<u>Dural Venous Sinuses:</u> Lateral View

A. Superior Sagittal Sinus

B. Great Cerebral Vein

C. Ophthalmic Veins

D. Facial Vein

E. Cavernous Sinus

F. Inferior Petrosal Sinus

G. Jugular Vein

H. Sigmoid Sinus

I. Superior Petrosal Sinus

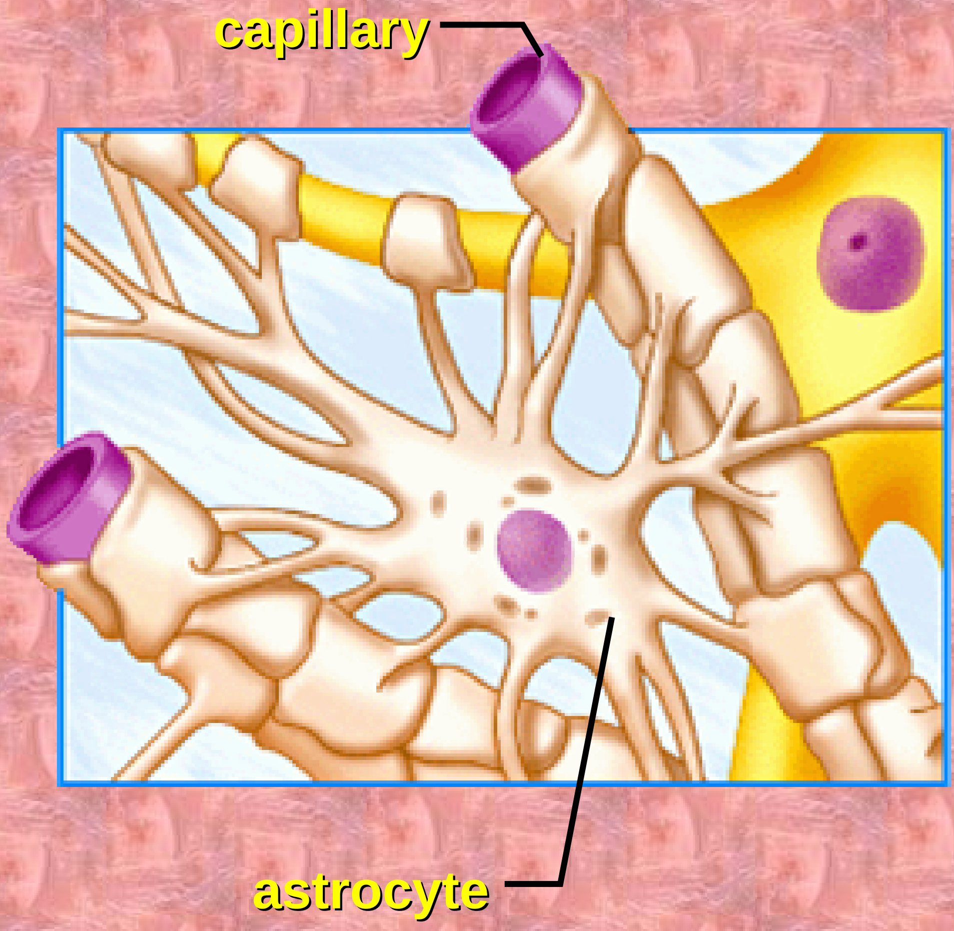
J. Transverse Sinus

K. Straight Sinus

L. Inferior Sagittal Sinus

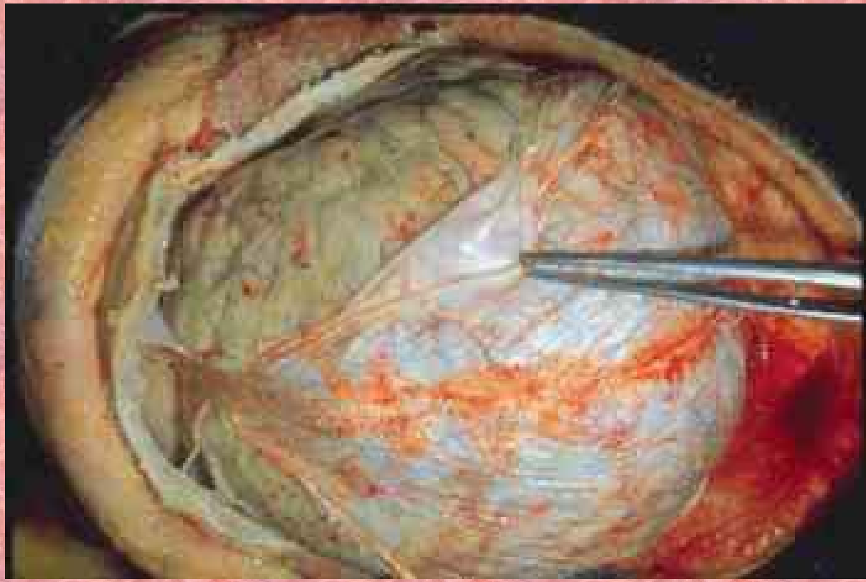
Blood-Brain Barrier

- Barrier formed by astrocytes and endothelial lining of brain capillaries
- Prevents cellular wastes from entering brain tissue

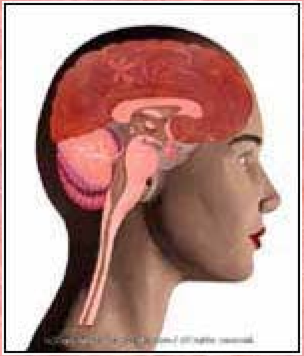


Disorders of the Meninges

- **Meningitis**
  - **Inflammation of the meninges caused by a viral or bacterial infection**
  - **May spread to nervous tissue of CNS**
- **Encephalitis**
  - **Brain tissue inflammation**
  - **Fatal 50% of the time**



- Pneumococcal Meningitis

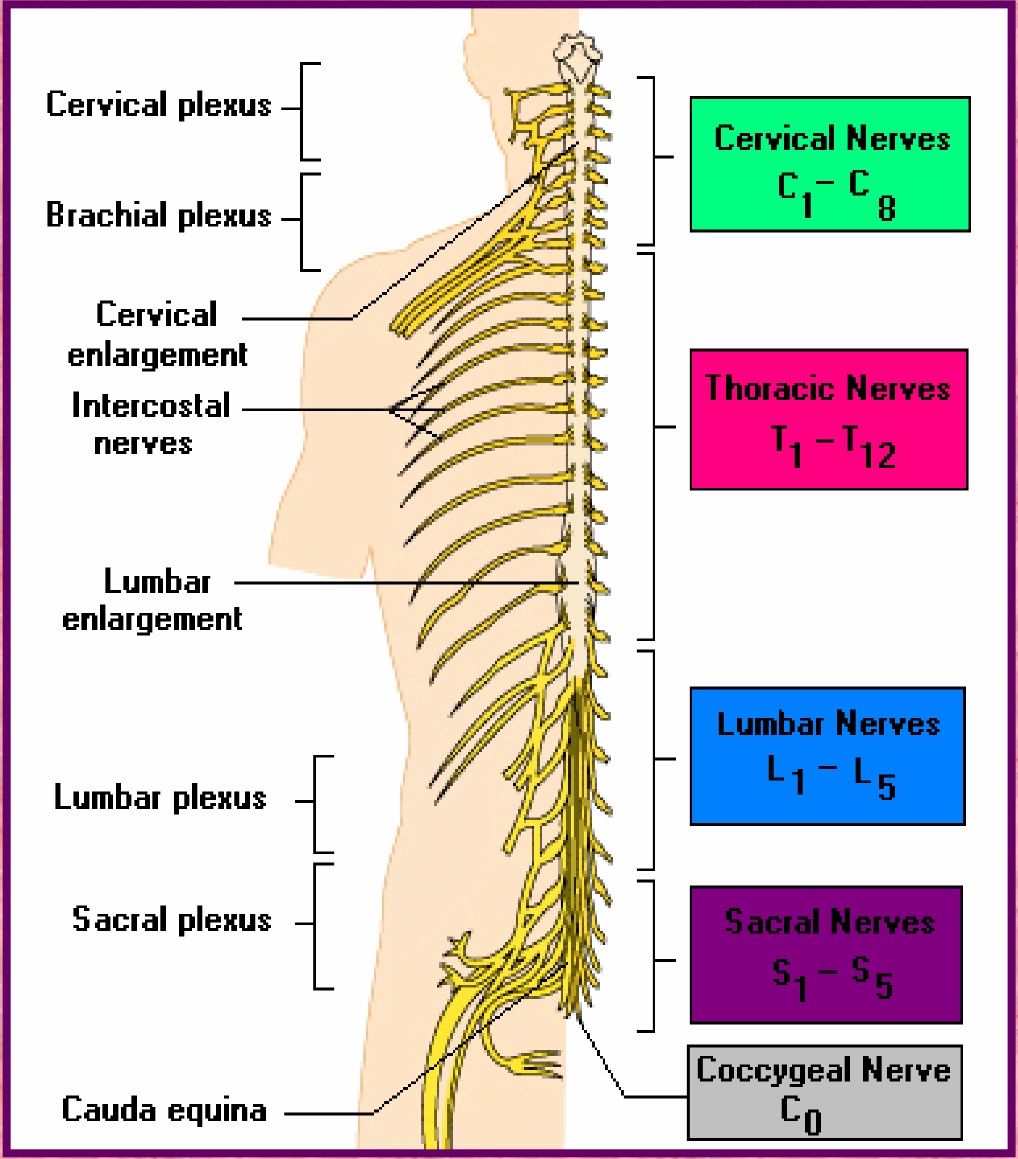


Disorders of the Meninges

- **Hydrocephalus**
  - **Build up of CSF due to blockage or obstruction**
  - **Exerts pressure on the brain**
  - **Can cause permanent brain damage**

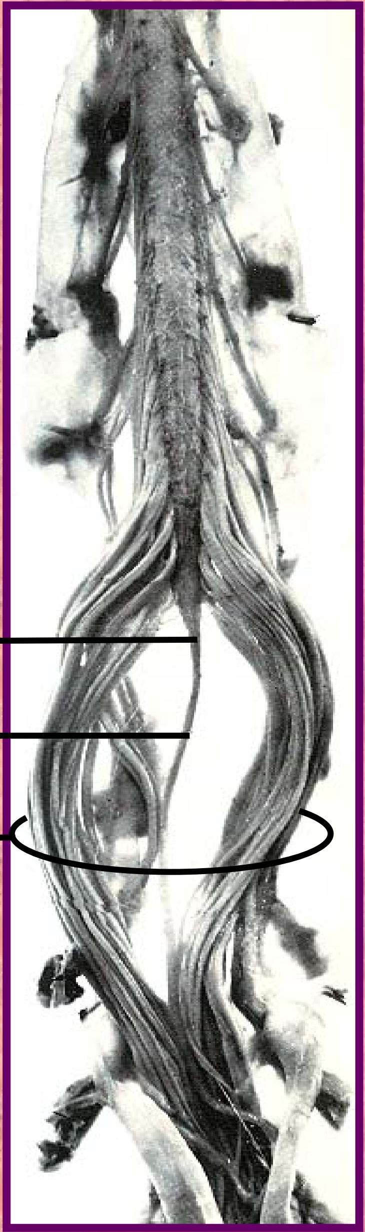
Spinal Cord

- **Function**
  - Controls reflex activities
  - Transmits info. from peripheral nerves to brain and back
- **Structure**
  - Runs from the foramen magnum to L_1 or L_2
  - Cervical and lumbar enlargements
  - 31 pair of spinal nerves emerge from the cord



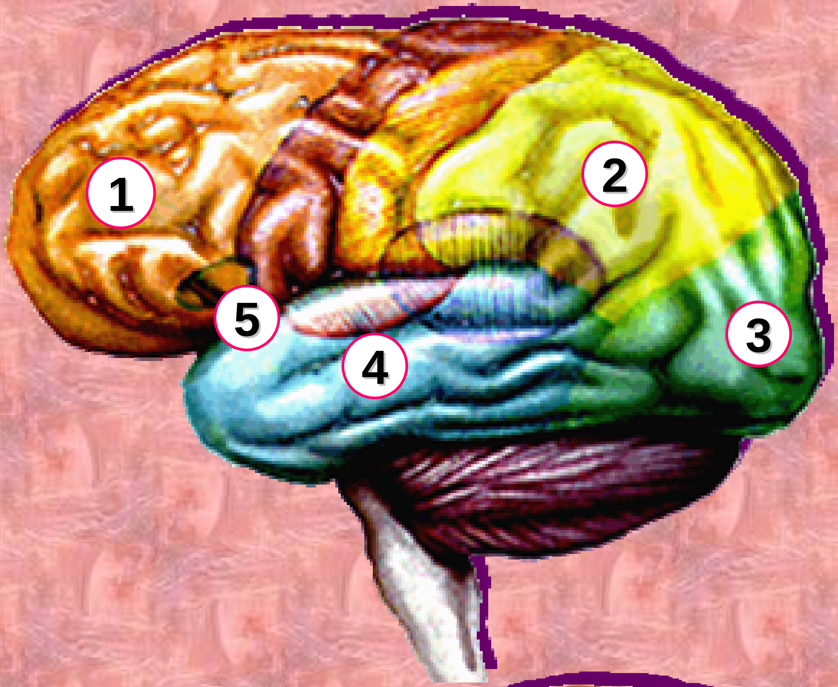
Spinal Cord Structure

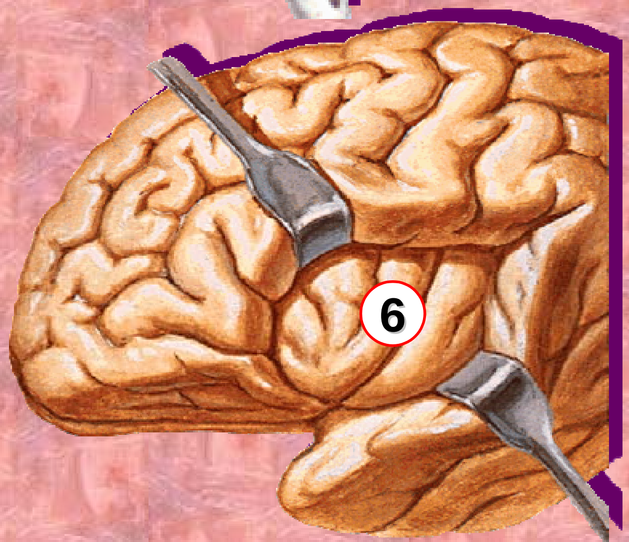
- **Filum Terminale**
  - **Extension of pia mater attaching the cord to the coccyx**
- **Conus Medullaris**
  - **Caudal end of spinal cord**
- **Cauda Equina**
  - **Nerves from the lower cord running inferior before exiting the vertebrae**

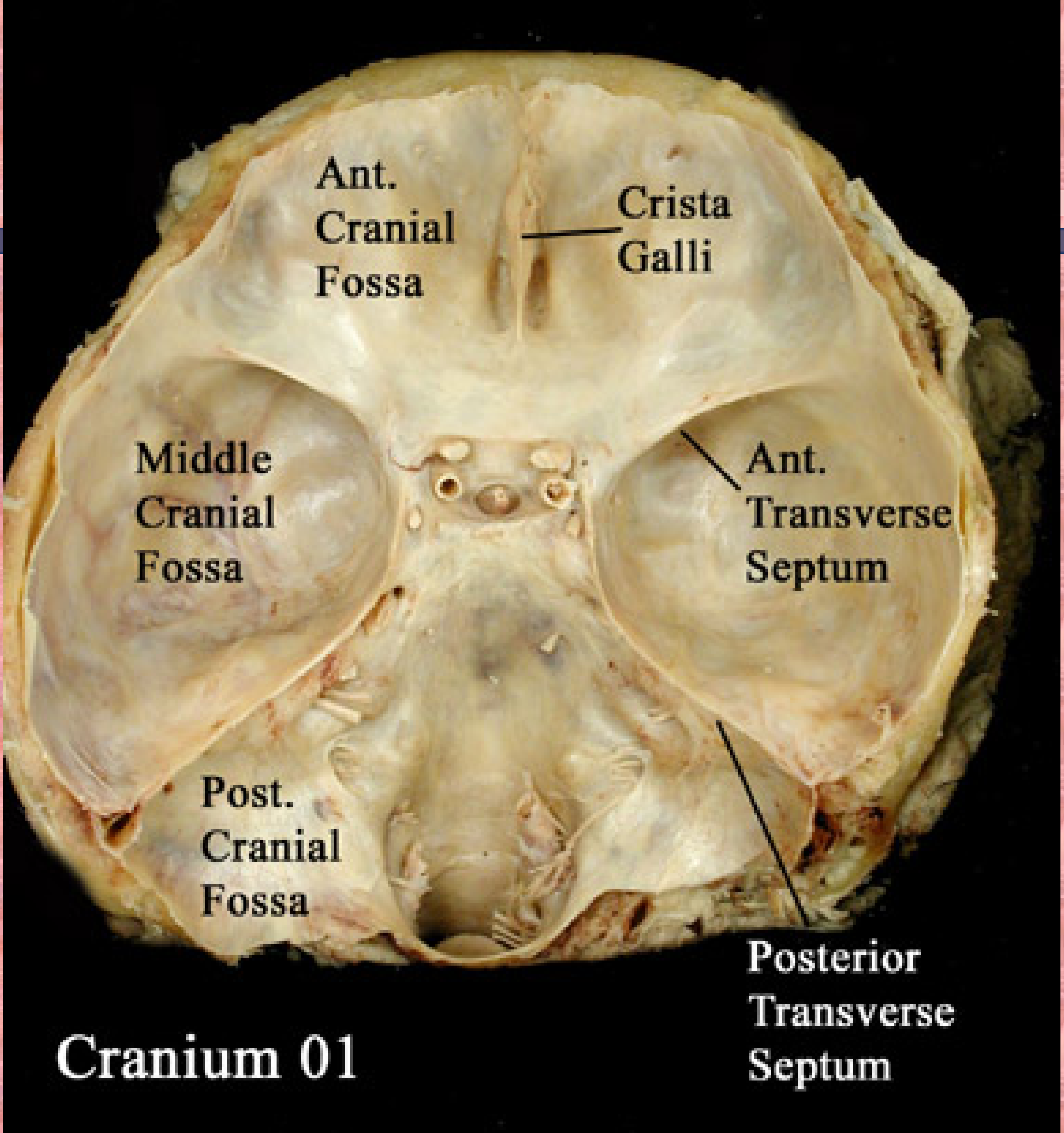


The Cerebrum: Regions

- Sits in anterior and middle cranial fossa
- Six lobes
  - Frontal (1)
  - Parietal (2)
  - Occipital (3)
  - Temporal (4)
  - Limbic (5)
  - Insula (6)
- Many functions in various regions

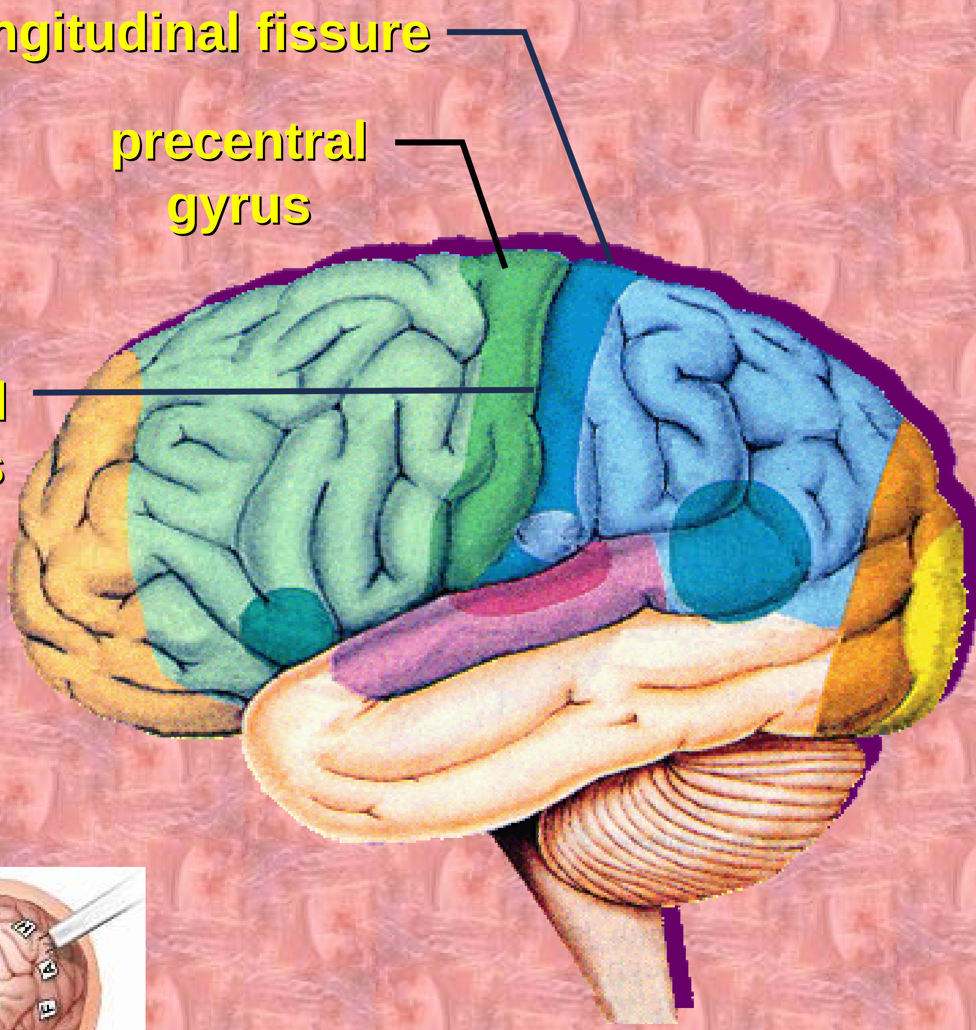


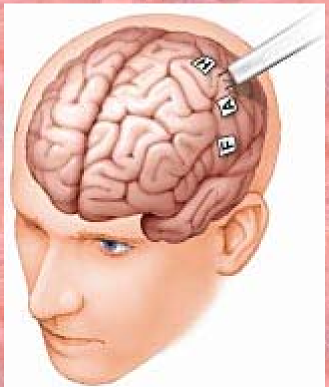



Ant.
Cranial
Fossa
Crista
Galli
Middle
Cranial
Fossa
Ant.
Transverse
Septum
Post.
Cranial
Fossa
Posterior
Transverse
Septum
Cranium 01

The Cerebrum: Gyri and Sulci

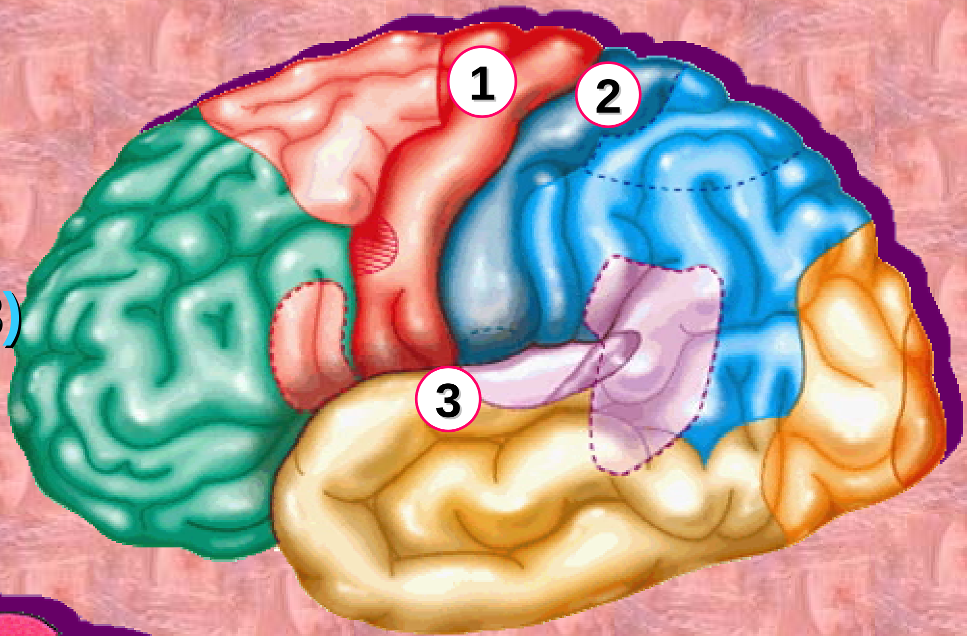
- **Gyri (gyrus)**
  - Folds or hills in the cerebral tissue
- **Sulci (sulcus)**
  - Shallow grooves or valleys
- **Fissures**
  - Deeper grooves and valleys

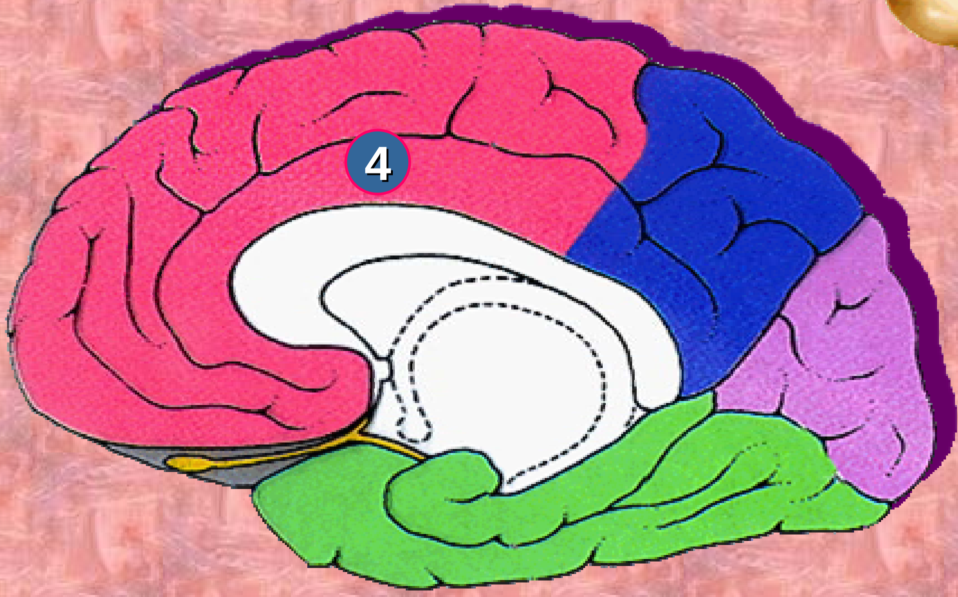




The Cerebrum: Gyri

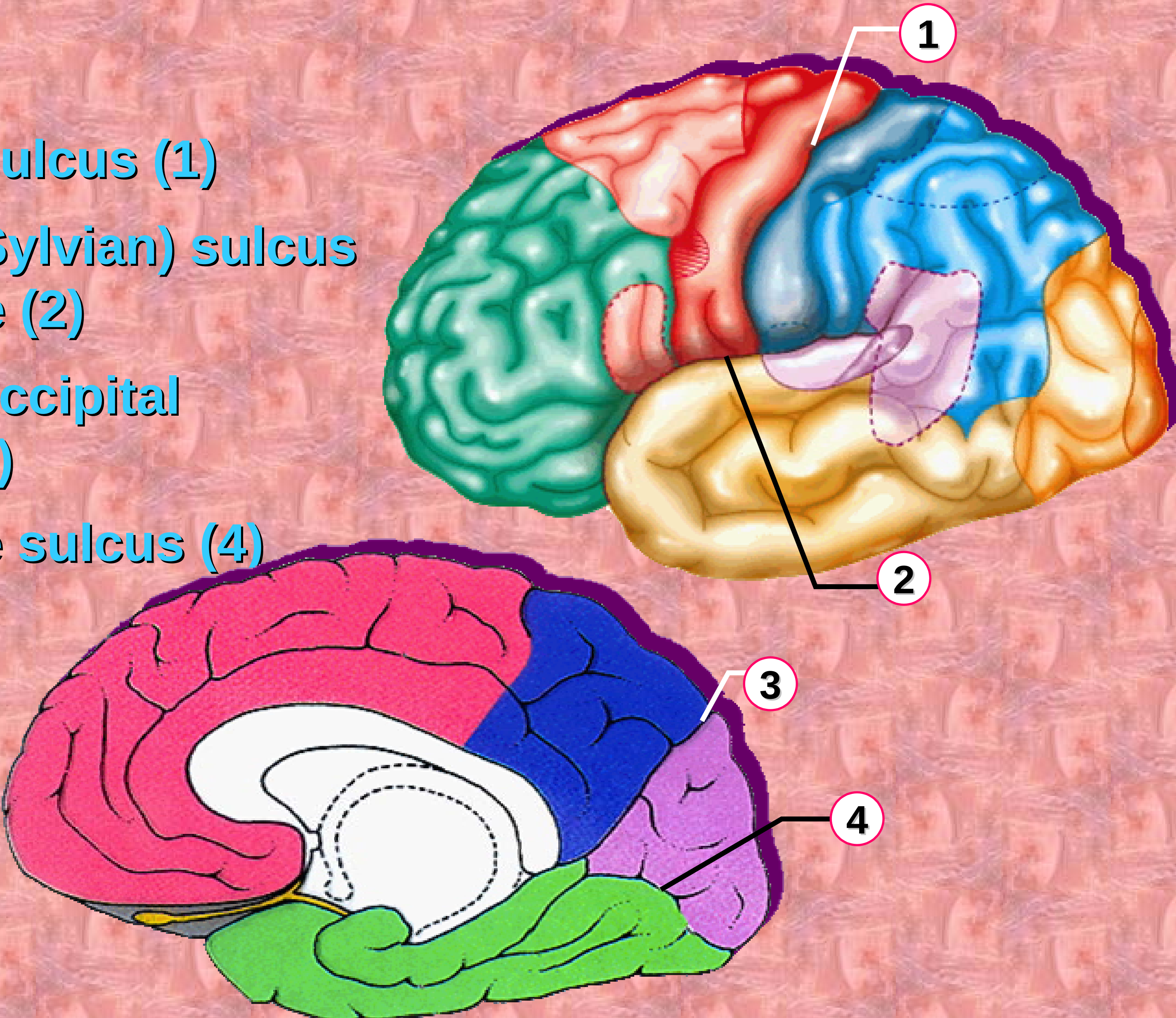
- **Gyri**
  - Precentral gyrus (1)
  - Postcentral gyrus (2)
  - Superior temporal gyrus (3)
  - Cingulate gyrus (4)

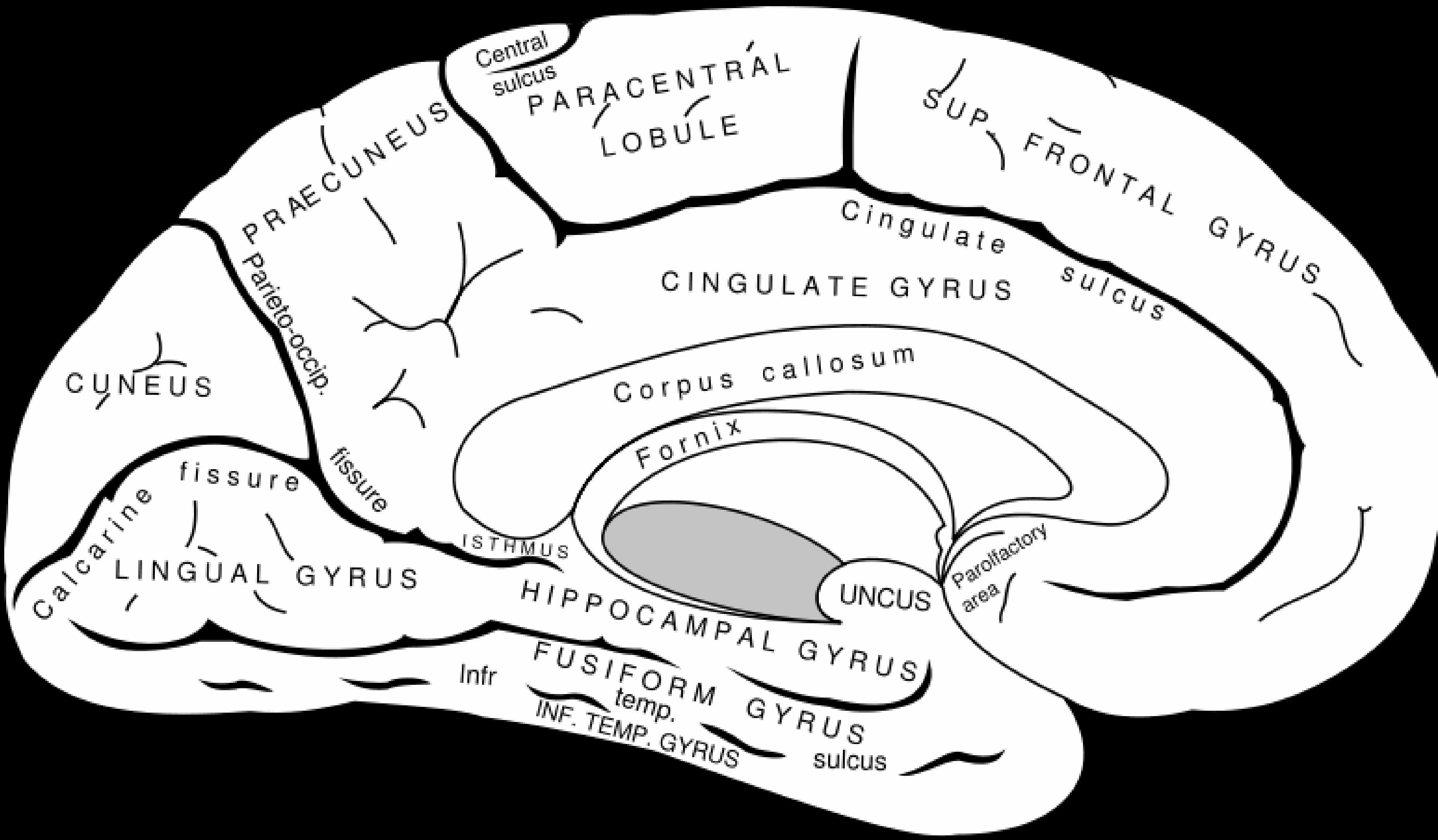




The Cerebrum: Sulci

- Sulci
  - Central sulcus (1)
  - Lateral (Sylvian) sulcus or fissure (2)
  - Parieto-occipital sulcus (3)
  - Calcarine sulcus (4)

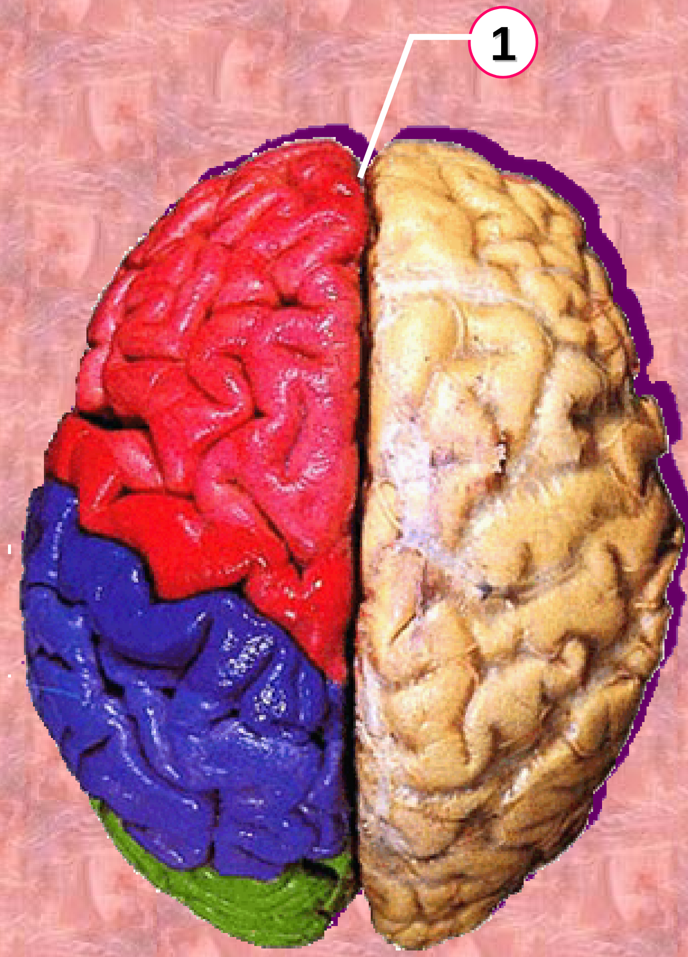


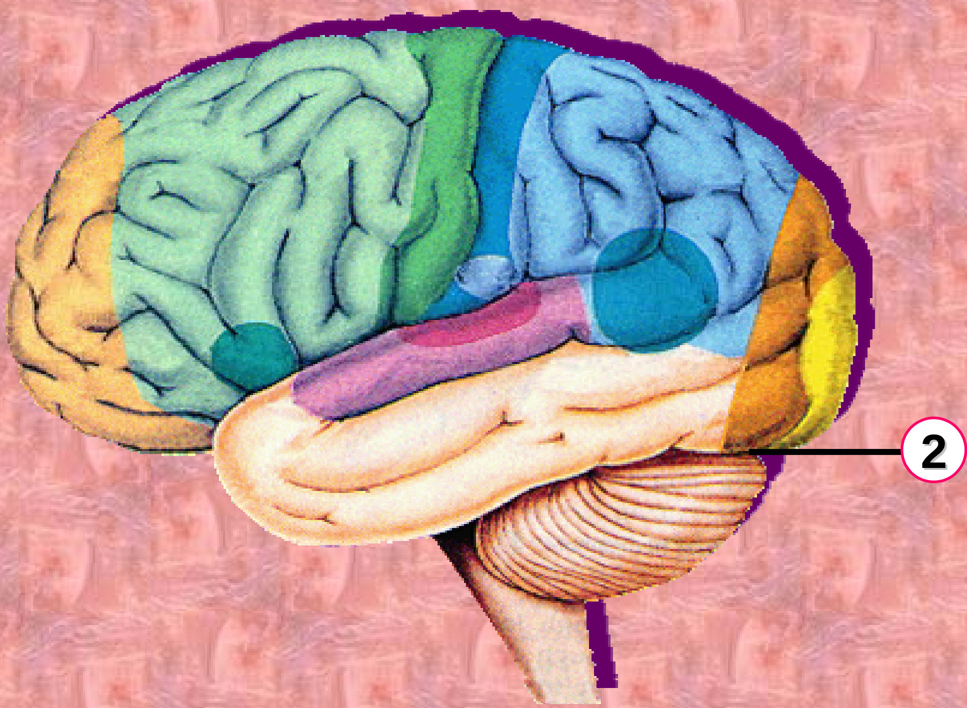


Central sulcus
PARACENTRAL LOBULE
PRAECUNEUS
SUP. FRONTAL GYRUS
Cingulate sulcus
CINGULATE GYRUS
Parieto-occip. fissure
CUNEUS
Corpus callosum
Fornix
Calcarine fissure
LINGUAL GYRUS
ISTHMUS
UNCUS
Parolfactory area
HIPPOCAMPAL GYRUS
FUSIFORM GYRUS
Infr temp. sulcus
INF. TEMP. GYRUS

The Cerebrum: Fissures

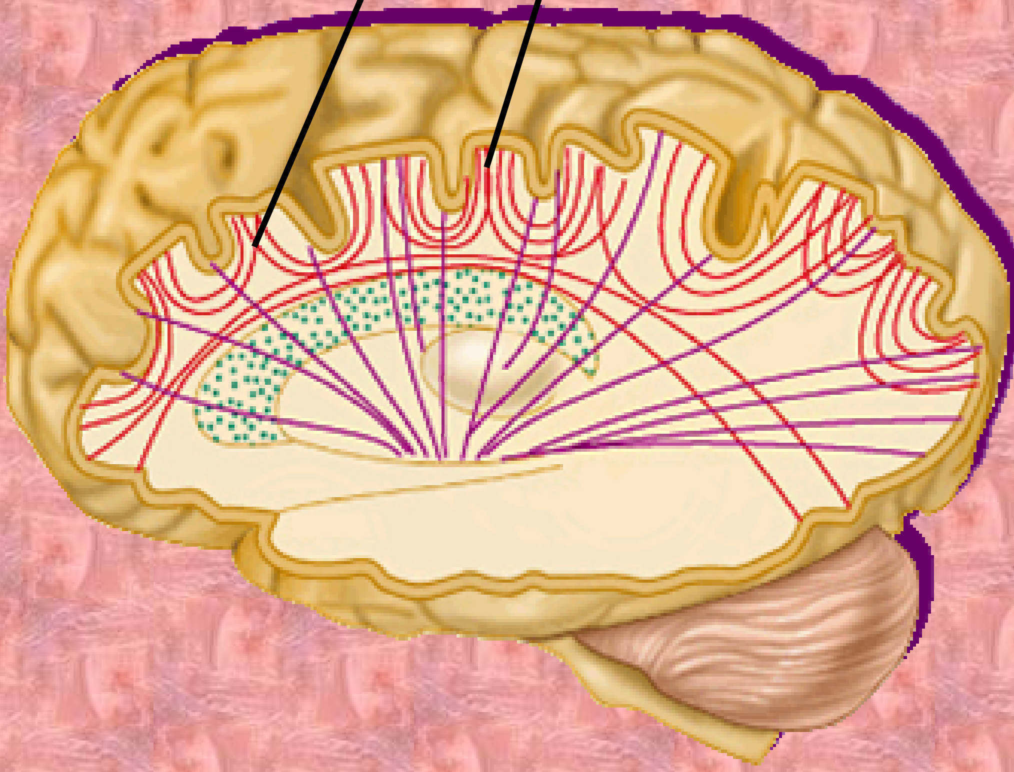
- **Fissures**
  - **Longitudinal fissure (1)**
  - **Transverse fissure (2)**





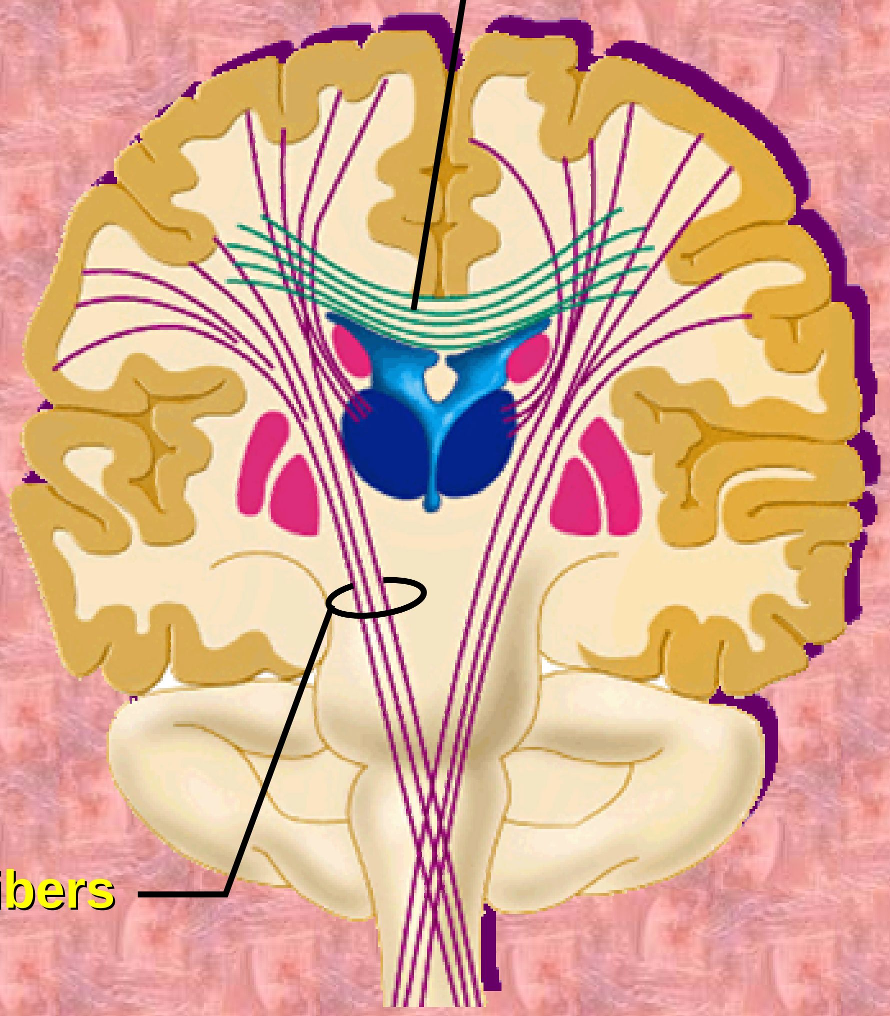
The Cerebrum: White matter

- White matter = myelinated axons
- Three types of fibers in cerebral white matter:
  - **Association fibers**
    - Travel to other areas in the same hemisphere



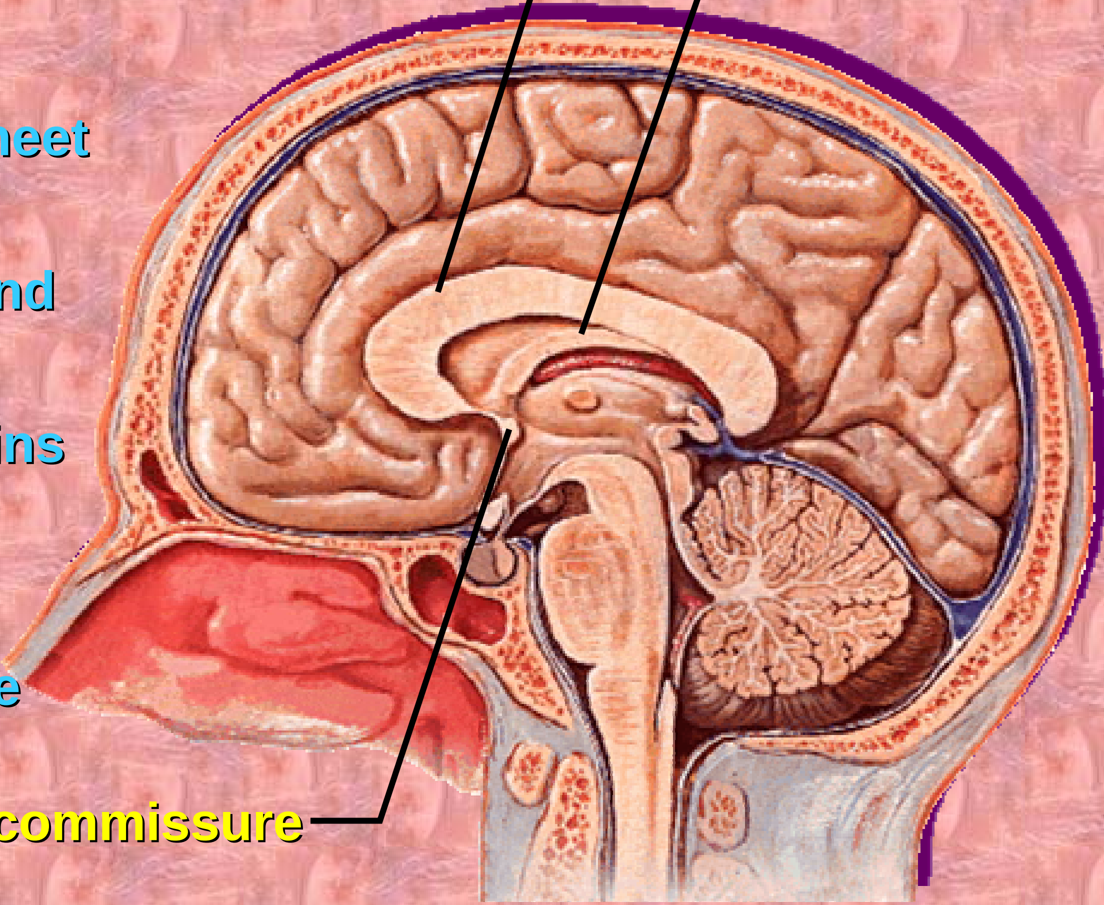
The Cerebrum: White Matter

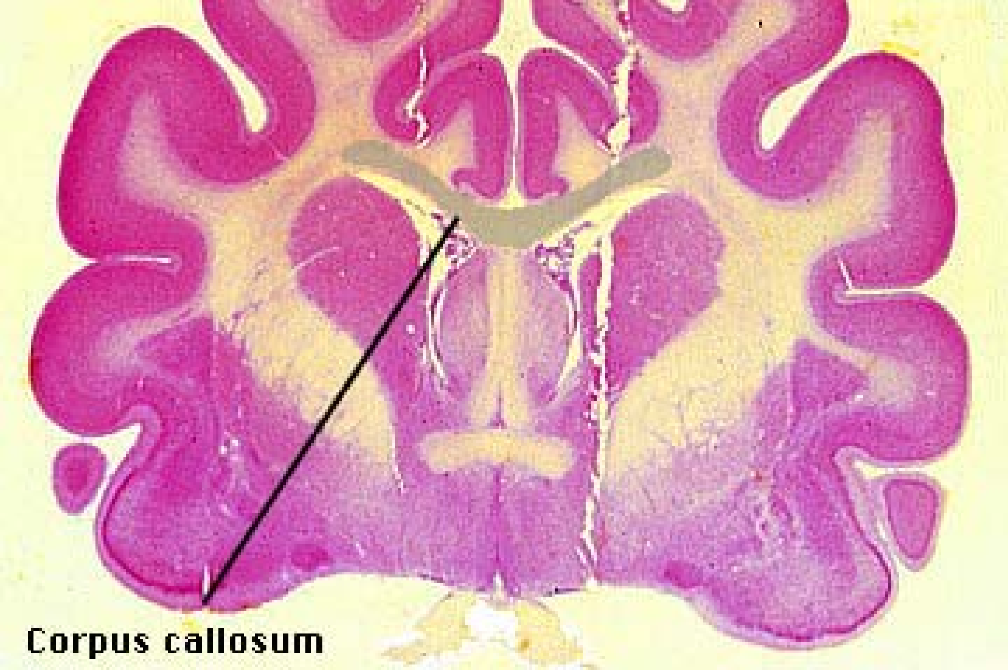
- **Commissural fibers**
  - Connect areas from one hemisphere to the other hemisphere
- **Projection fibers**
  - Descend from cortex towards lower brain or spinal cord



The Cerebrum: White Matter

- **Commissures**
  - **Regions with commissural fibers**
    - **Corpus callosum- sheet like nerve tract that connects the right and left cerebral hemispheres (contains more than 2 million axons.**
    - **Anterior commissure**




Corpus callosum

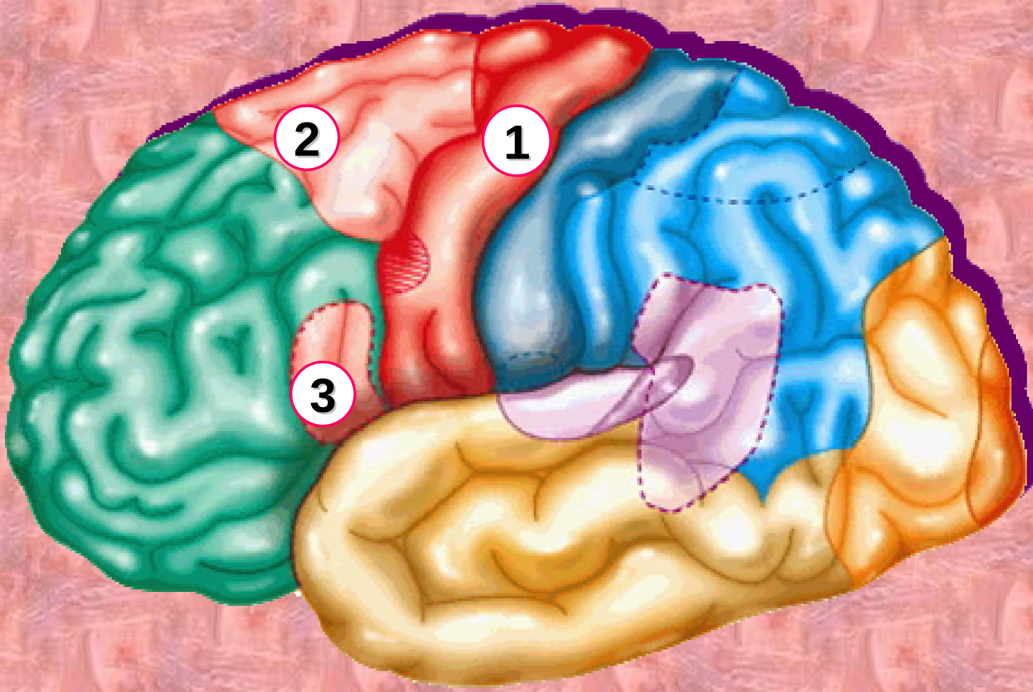

Anterior commissure

Cerebrum: Functions

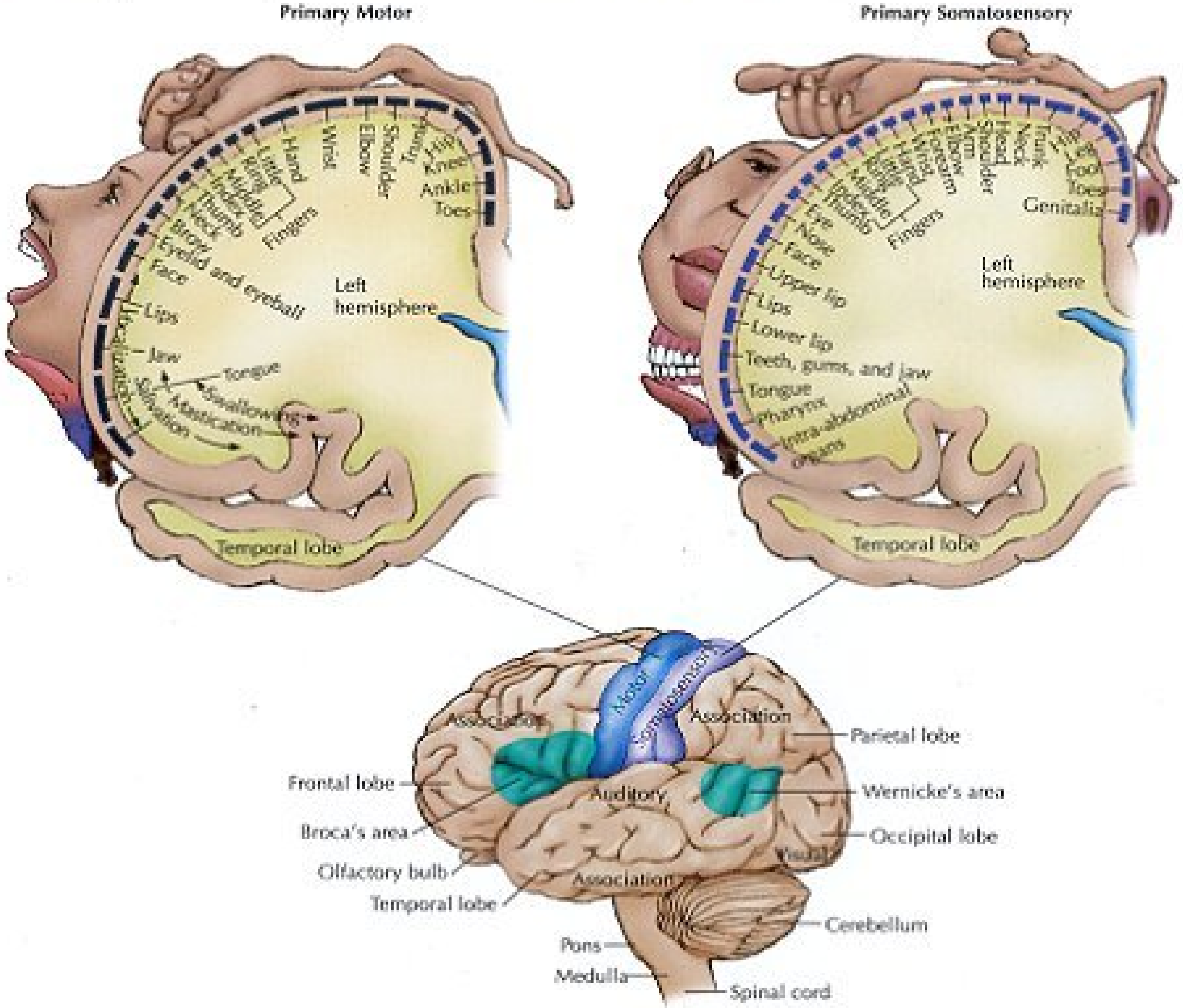
- **Three Functional Types of Areas Within the Cerebrum:**
  - À **Sensory Areas**
    - **Conscious awareness of sensations**
  - **Motor Areas**
    - **Control voluntary functions**
  - **Association Areas**
    - Control our ability to understand sensory information and coordinate a response
      - Somatic sensory association area
      - Visual association area
      - Somatic motor association area

Cerebral Lobes: Function

- **Frontal Lobe**
  - **Primary Motor Cortex (1)**
    - **Precentral gyrus**
    - **Allows conscious control of skeletal muscle**
    - **Contralateral innervation**
- Damage - paralysis on opposite side of body



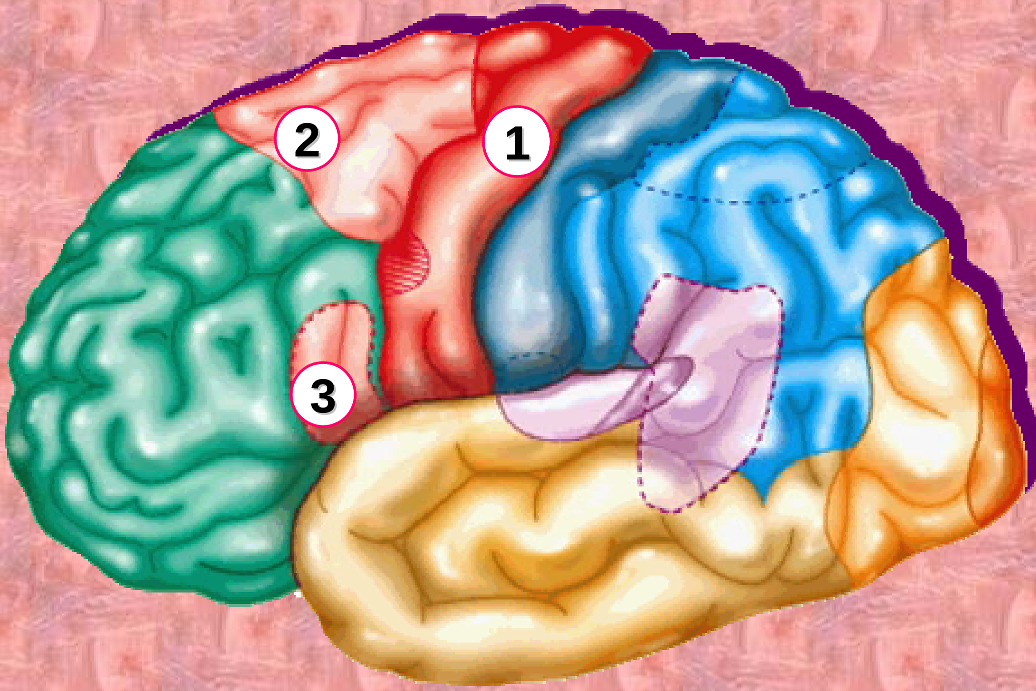
Primary sensory, motor, and association areas of the cerebral cortex



Motor Homunculus

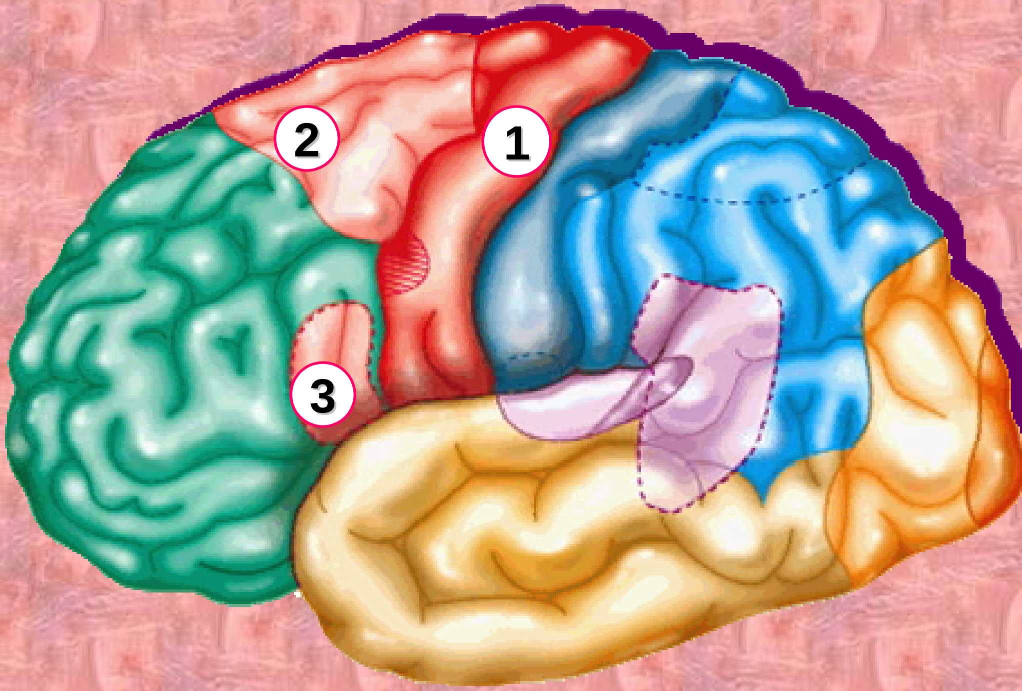
Frontal Lobe: Broca's Area (3)

- At the base of the premotor cortex usually in only the left hemisphere
- a. Activates in proper sequence the muscles of speech (lips, tongue, throat)
- b. Damage - expressive aphasia; lacking speech as the muscles are not properly activated
- c. Seen in strokes with right side paralysis



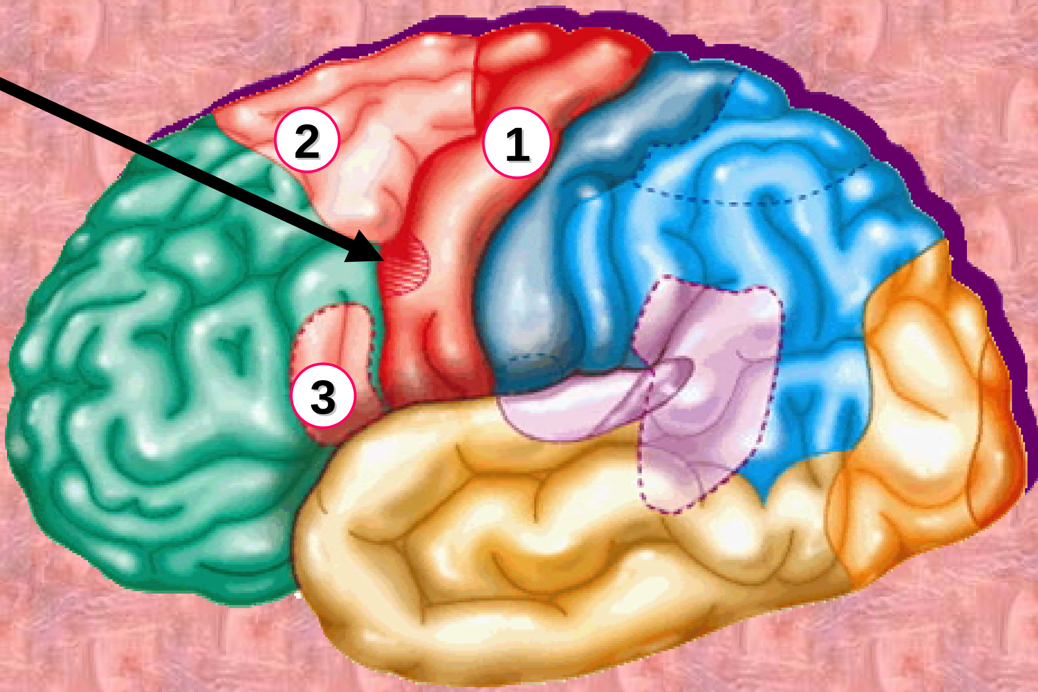
Frontal Lobe: Premotor Area

- Premotor Area (2)
  - Controls learned, repetitious motor skills : typing
- Damage - loss of programmed motor skill; you can type, but not with the usual dexterity.



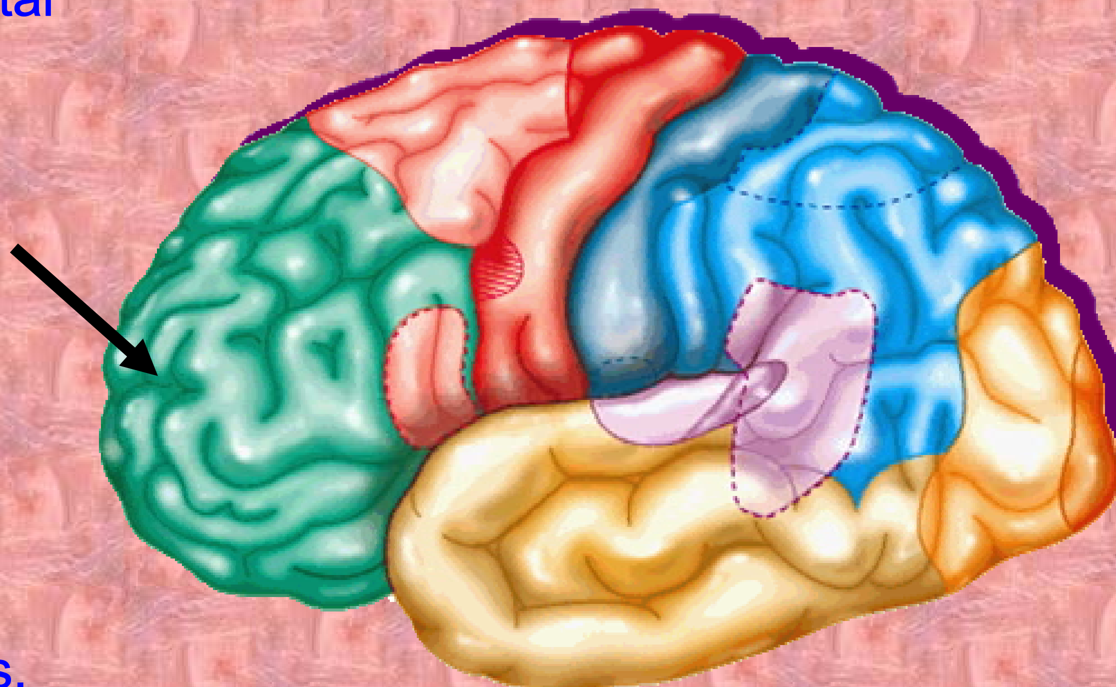
Frontal Lobe: Frontal Eye Field

- Frontal eye field - anterior to the premotor cortex and superior to Broca
- a. Controls voluntary eye movements



Frontal Lobe: Prefrontal Cortex

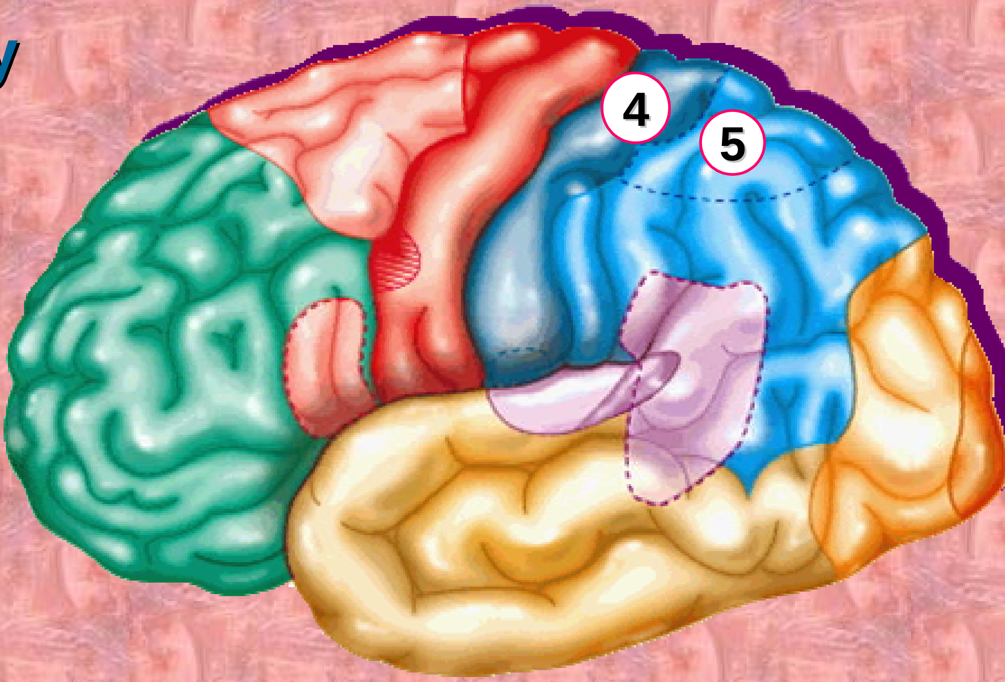
- In the anterior part of the frontal lobe
- a. Involved with thought, intelligence, motivation, personality, judgment, persistence, planning, conscience and concern for others
- b. Matures slowly and is dependent on positive and negative feedback.
- c. Damage - mood swings, loss of attentiveness and judgment, etc.



Cerebral Lobes: Parietal Lobe

- **Parietal Lobe**
  - **Primary Somatosensory Cortex (4)**
    - **Postcentral gyrus**
    - **Receives input from sensory receptors in skin, muscles**
      - Touch, pressure, pain

        taste,temperature
    - **I.D. body region input is from**

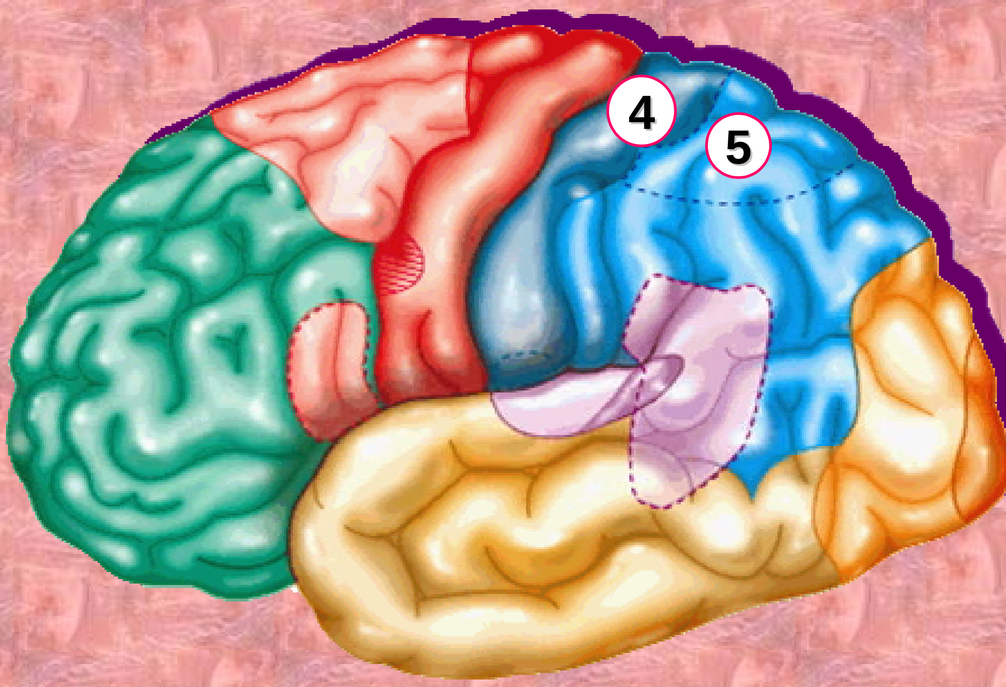


- Damage - can’t determine the site of the stimulus

Cerebral Lobe: Parietal Lobe

◆ **Sensory Association Area (5)**

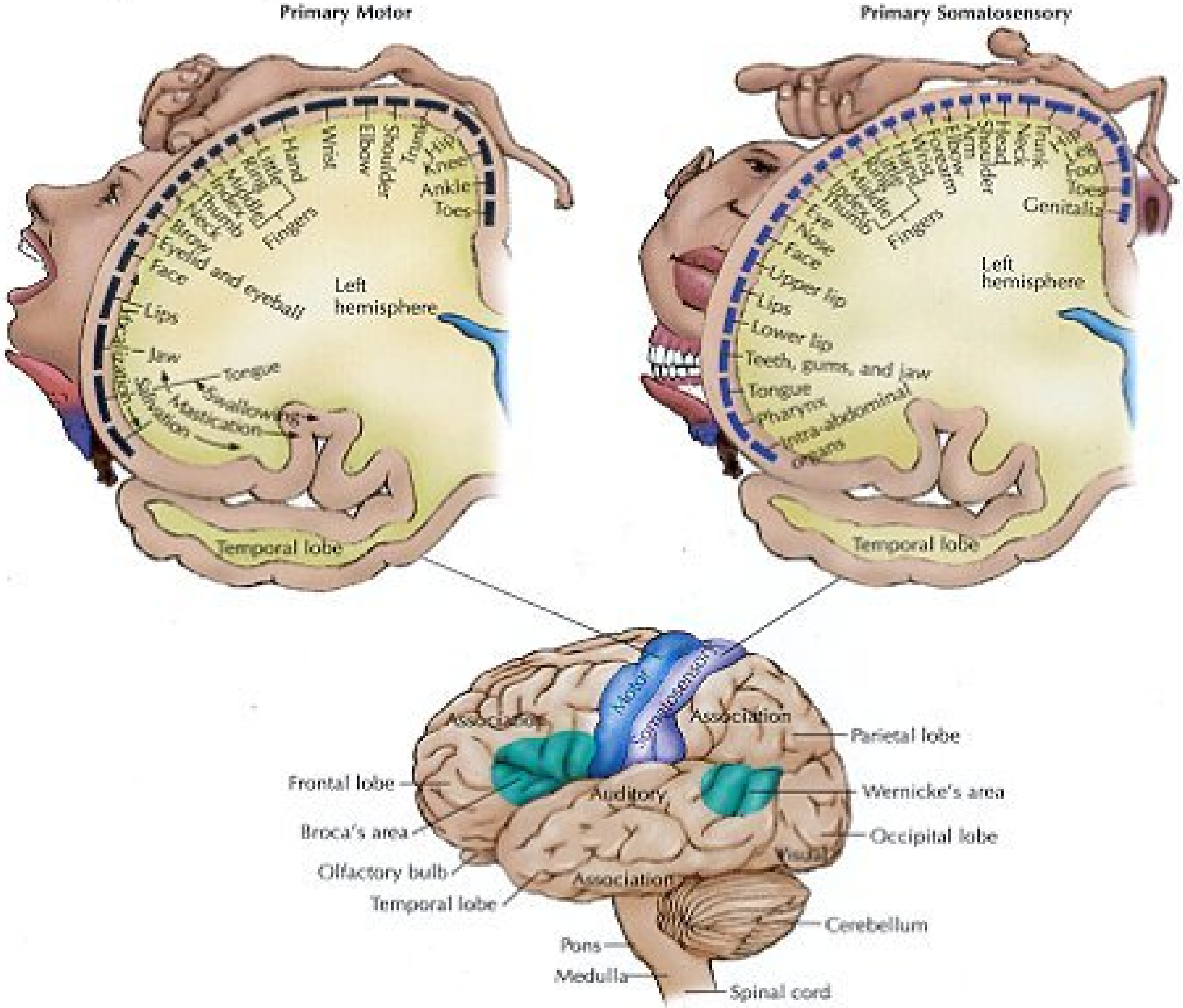
- Integrates and analyzes sensory input based on past experience
- Evaluates size, texture, relationships etc.



Damage –

- astereognosis – the inability to recognize a small object by palpation, without the aid of vision.
- Interferes with the ability to appreciate the **meaning** of a stimulus.

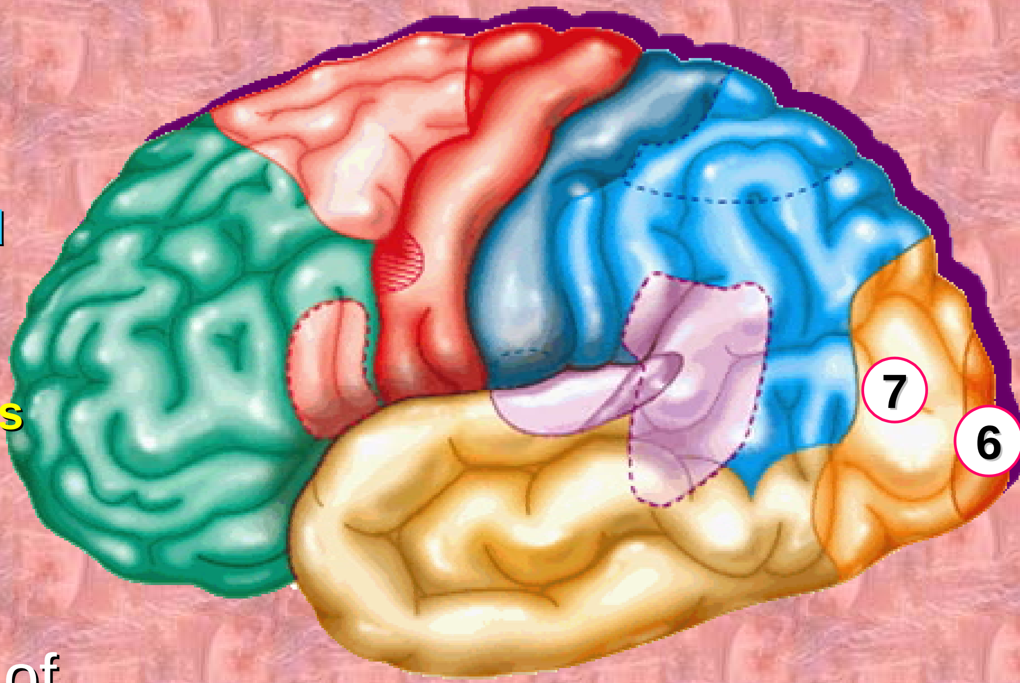
Primary sensory, motor, and association areas of the cerebral cortex



Sensory Homunculus

Cerebral Lobes: Occipital Lobe

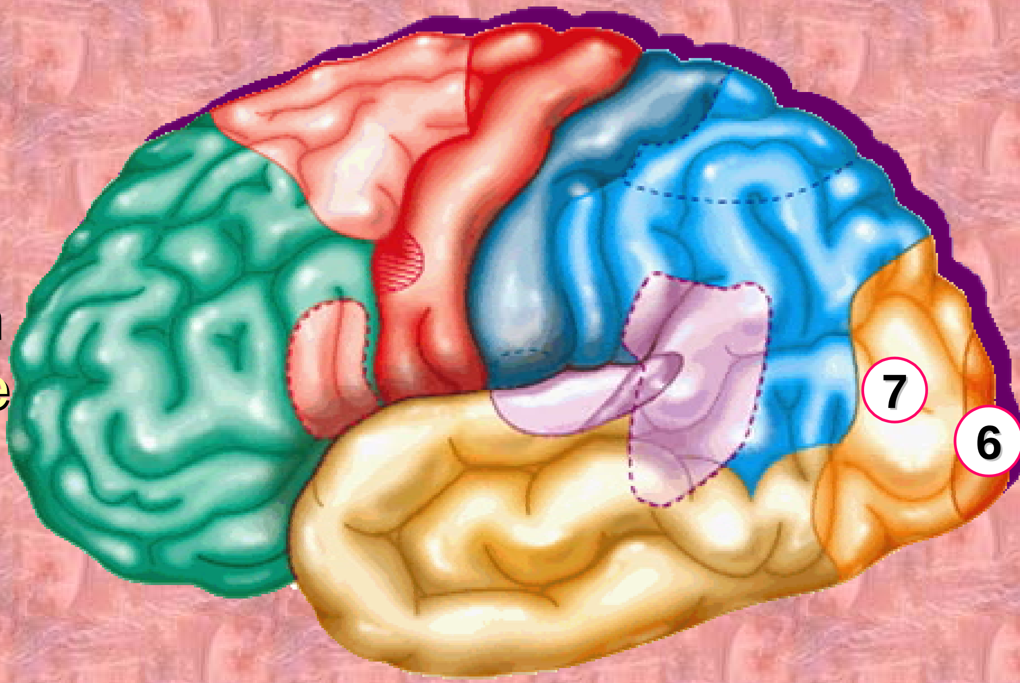
- **Occipital Lobe**
  - **Primary Visual Cortex (6)**
    - **Posterior occipital lobe (calcarine sulcus)**
    - **Receives input from retina regarding shape, color, and movement**
    - **Info relayed through lateral geniculate body of thalamus**



•Stimulation - visual hallucinations seeing flashes of light, stars & other geometric forms

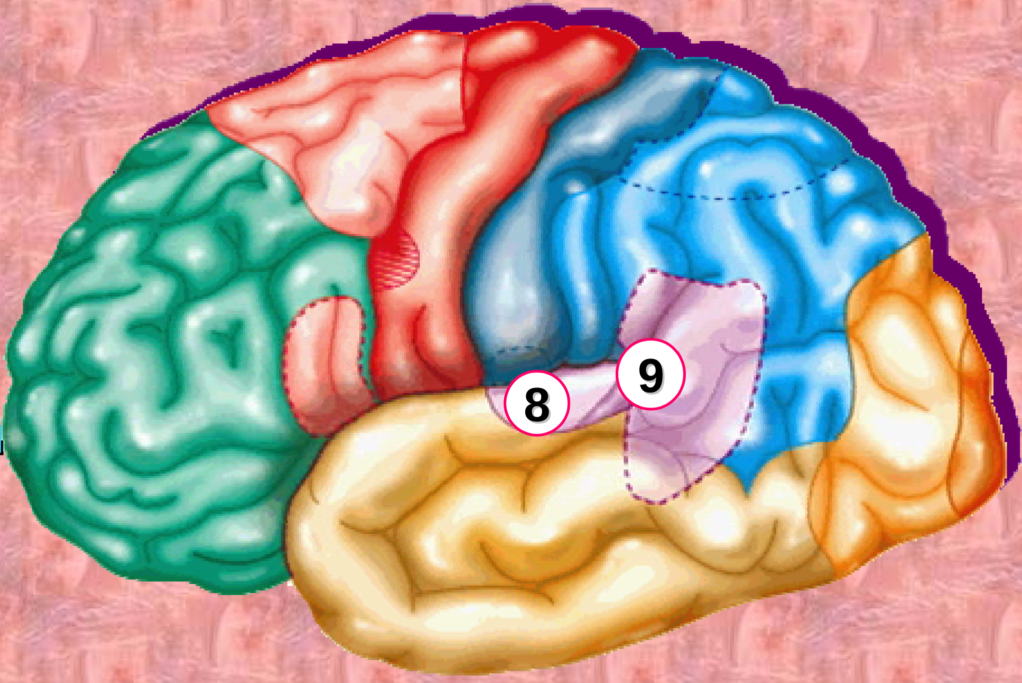
Cerebral Lobes: Occipital Lobe

- Visual Association Area (7)
  - Surrounds visual cortex
  - Interprets visual inputs, uses past experiences
  - Allows for visual recognition and appreciation of what we see
- Stimulation - complex hallucinations - see animals and people and react with fear or laughter
- Damage - visual agnosia - can't understand what one sees.



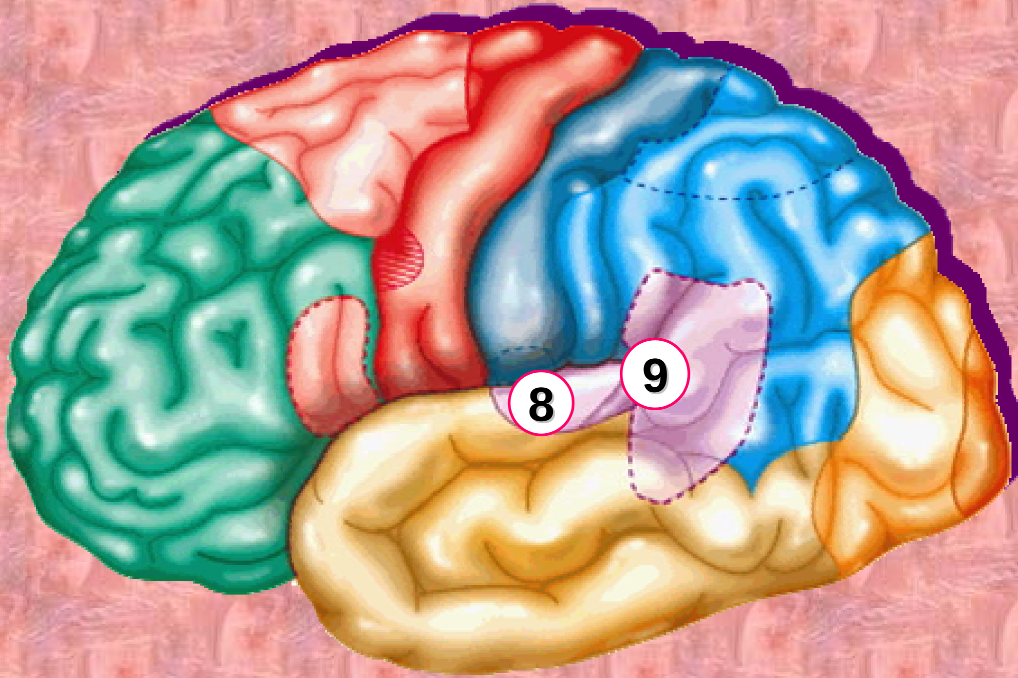
Cerebral Lobes: Temporal Lobe

- **Temporal Lobe**
  - **Primary Auditory Cortex (8)**
    - **Superior temporal gyrus**
    - **Receives info. from receptors in inner ear for sound**
    - Relates to pitch , rhythm and loudness
- Stimulation - auditory hallucinations - birds flapping their wings, waterfalls, etc



Cerebral Cortex:Temporal Lobe

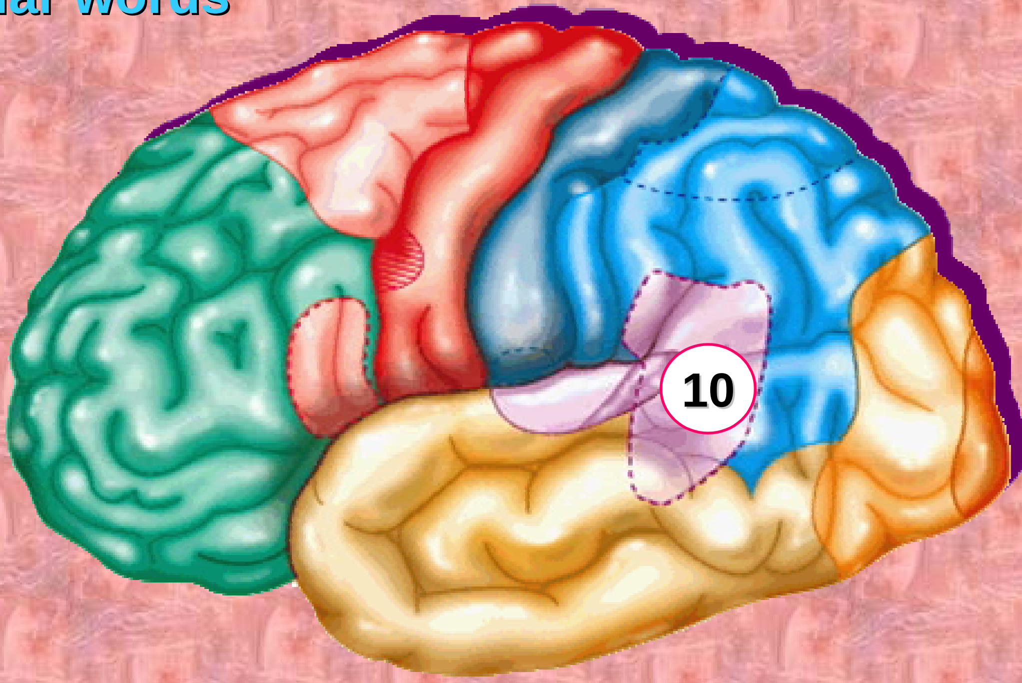
- Auditory Association Area (9)
  - Uses memories of sounds for sound recognition
- Stimulation - complex auditory hallucinations - hear conversations or songs from the past



Cerebral Lobes: Temporal Lobe

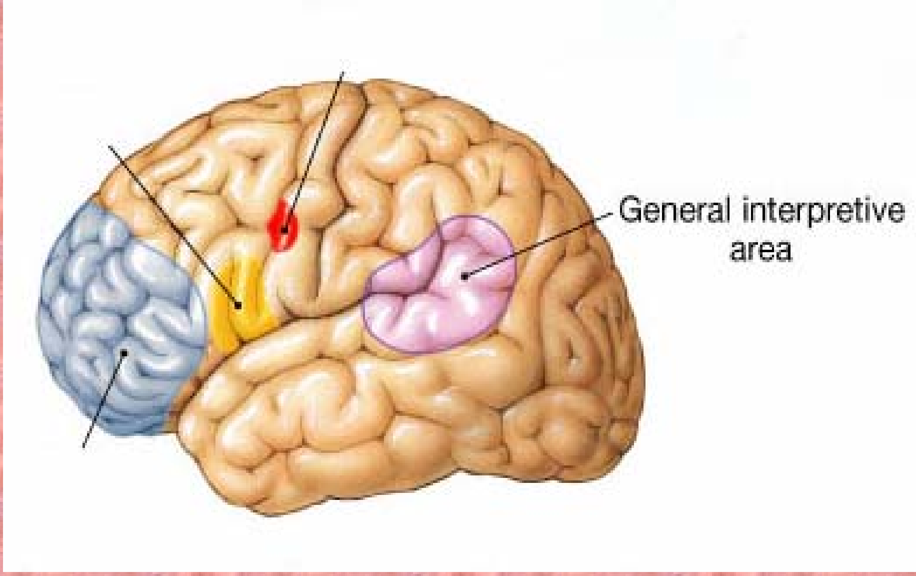
- **Posterior Temporal Lobe**
  - **Wernicke's Area (10)**
    - **Allows for the comprehension of written and spoken language**
    - **Sounding out unfamiliar words**

- An association tract runs from Wernicke to Broca.
- Damage - sensory (receptive) aphasia - can speak but can't understand spoken or written language



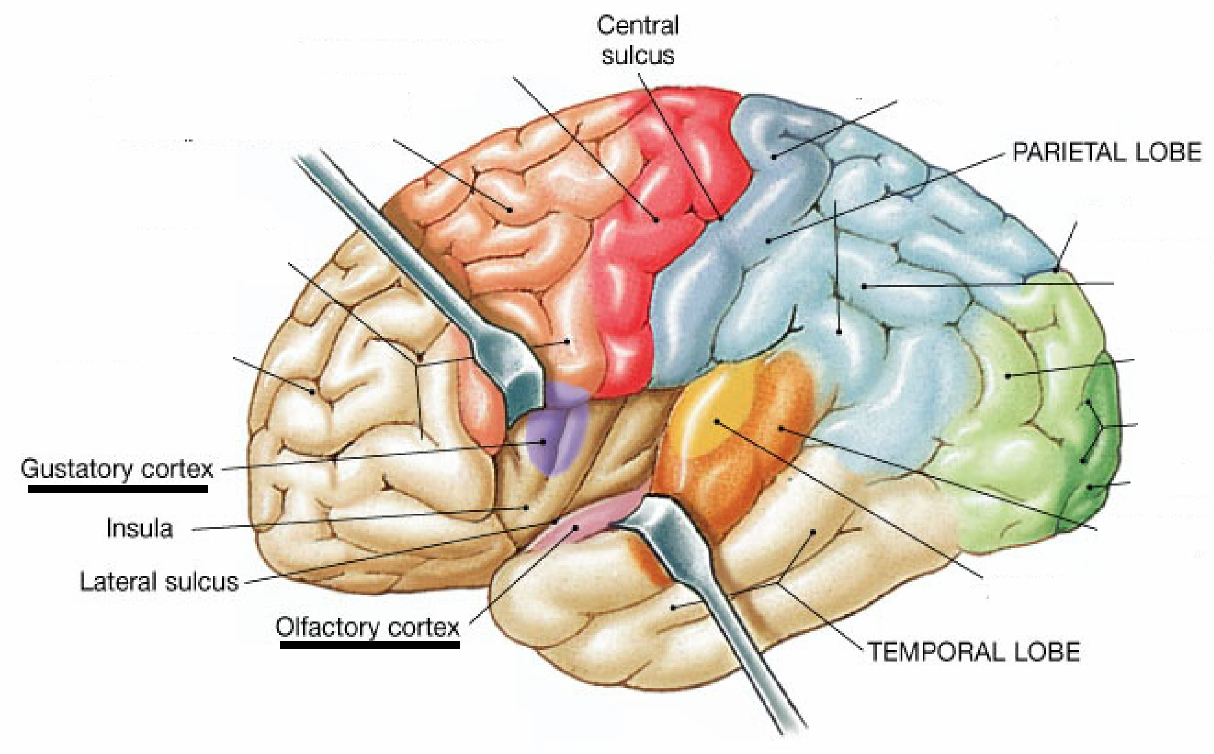
Cerebral Lobe: Temporal Lobe

- General interpretation area – in the superoposterior part of the temporal lobe in the left hemisphere generally
- a. Receives info from all sensory areas and stores complex memory patterns associated with the sensations.
- b. It integrates all incoming signals into a single understanding and then activates a response.
- c. Damage - become imbecilic; can't interpret a situation



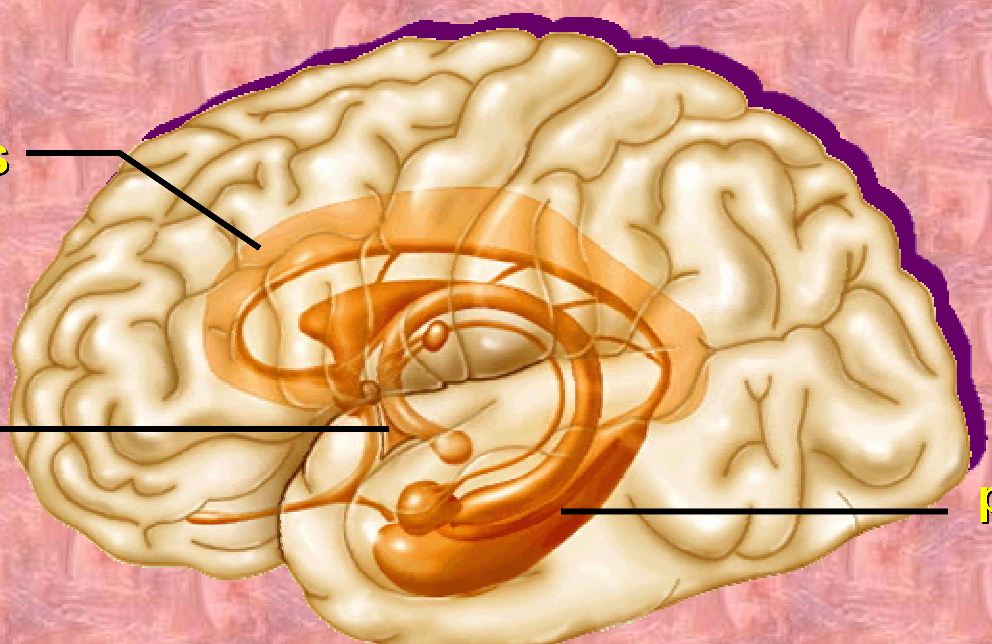
Cerebral Lobe: Temporal Lobe

- Olfactory area - medial part of the temporal lobe
  - Interprets smell
- Gustatory area - in the parietal lobe
  - Interprets taste



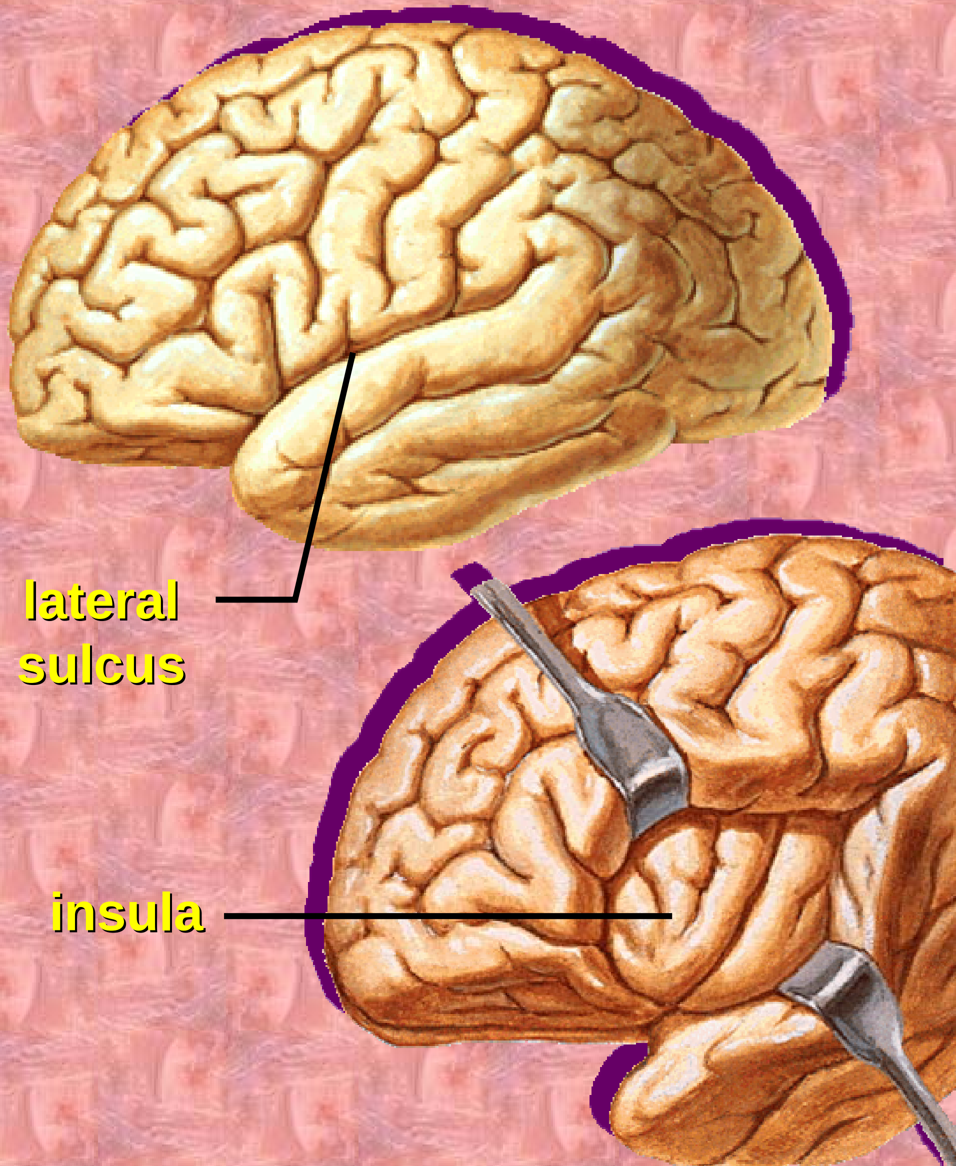
Cerebrum: functions

- **Limbic Lobe**
  - **Cingulate gyrus, parahippocampal gyrus, hypothalamus and part of the thalamus**
  - **“Emotional brain”**
  - **Extensive link to lower and higher brain areas**
  - **Allows emotional and visceral responses to things we are consciously aware of**



Cerebral Lobes: Function

- **Insula**
  - **Deep within the cerebrum in area deep to lateral sulcus**
  - **May be involved with autonomic and somatic activities**



The cerebrum

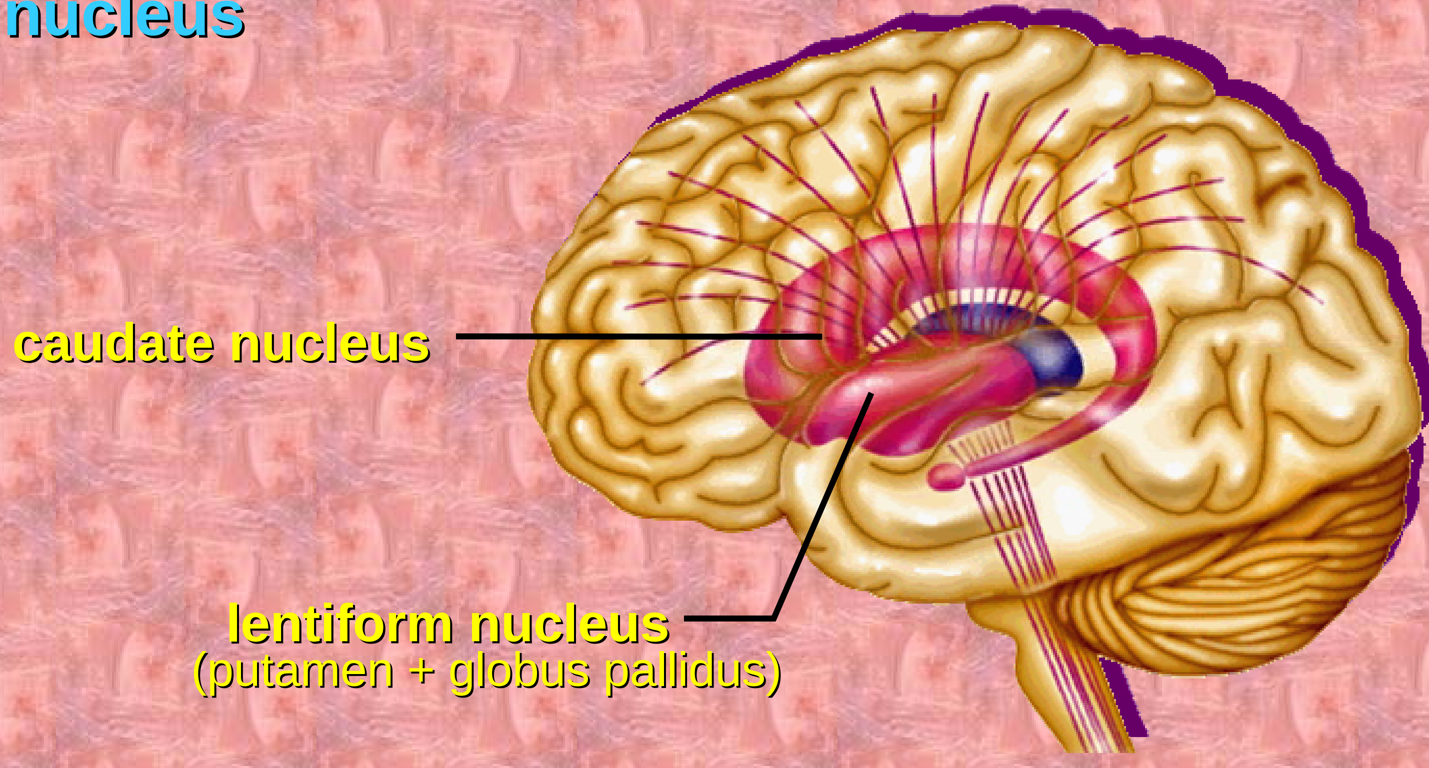
- **Aphasias**
  - **Inability to speak in grammatical sentences due to lesions in Broca's area**
- **Electroencephalograph (EEG)**
  - **Used to trace patterns of brain activity**
  - **Can be used to detect regions where seizures are occurring**

The Cerebrum: Gray Matter

- **Cerebral Cortex**
  - **Gray matter**
    - **Neuron cell bodies**
    - **Outer layer of cerebrum**
  - **Gray matter also in basal nuclei**

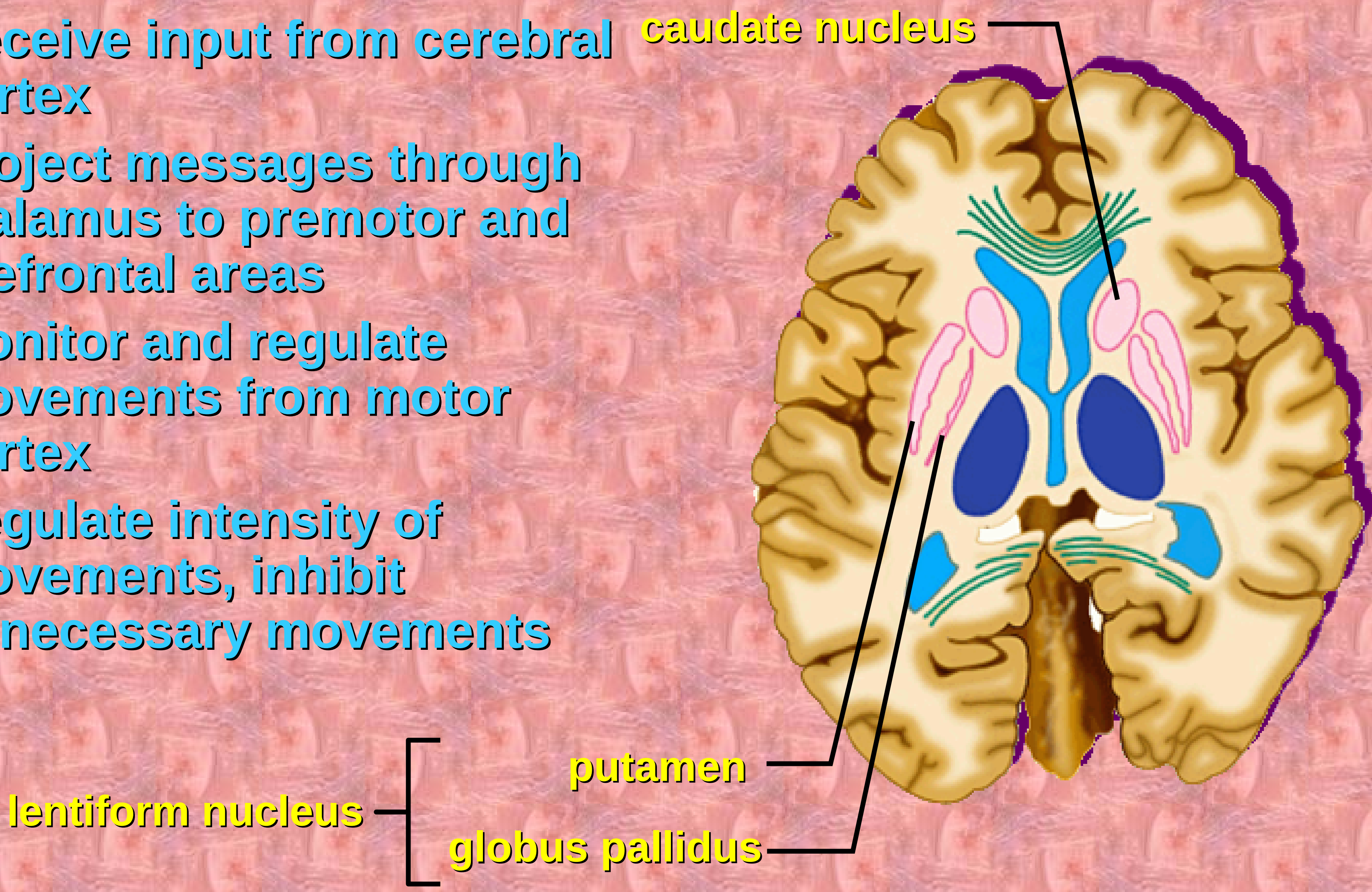
The Cerebrum: Basal Nuclei

- Also called **basal ganglia**
- Areas of gray matter deep within the cerebrum
  - Putamen, globus pallidus, caudate nucleus



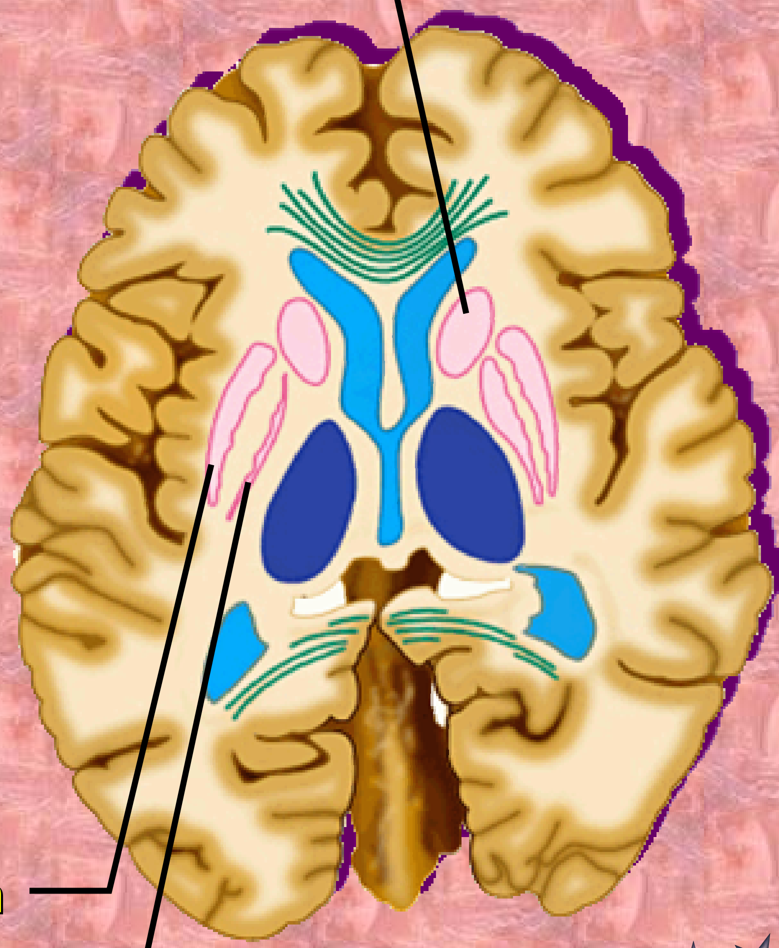
The Cerebrum: Basal Nuclei

- Receive input from cerebral cortex
- Project messages through thalamus to premotor and prefrontal areas
- monitor and regulate movements from motor cortex
- Regulate intensity of movements, inhibit unnecessary movements



The Cerebrum: Basal Nuclei

- Assoc. with the subthalamic nuclei and substantia nigra (Parkinson's disease)
- Damage to the Basal Nuclei
  - disturbance in posture and muscle tone
  - Involuntary movements, like tremors
  - Abnormal slowness of movement



Basal Ganglia

Responsible for:

- Selecting and maintaining purposeful motor activity while <u>suppressing unwanted or useless movement.</u>
- Helping monitor and coordinate slow, sustained contractions related to posture and support.
- Inhibiting muscle tone throughout the body (proper muscle tone is normally maintained through a balance of excitatory and inhibitory inputs to the neurons that innervate skeletal muscle).
- Although there are many different neurotransmitters used within the basal ganglia (principally ACh, GABA, and dopamine)

Basal Ganglia

- The function of the basal ganglia is often described in terms of a "brake hypothesis".
- To sit still, you must put the brakes on all movements except those reflexes that maintain an upright posture.
- To move, you must apply a brake to some postural reflexes, and release the brake on voluntary movement.
- In such a complicated system, it is apparent that small disturbances can throw the whole system out of whack, often in unpredictable ways.
- The deficits tend to fall into one of two categories:
  - the <u>presence of extraneous unwanted movements</u>
  - or an *absence or difficulty with intended movements.*

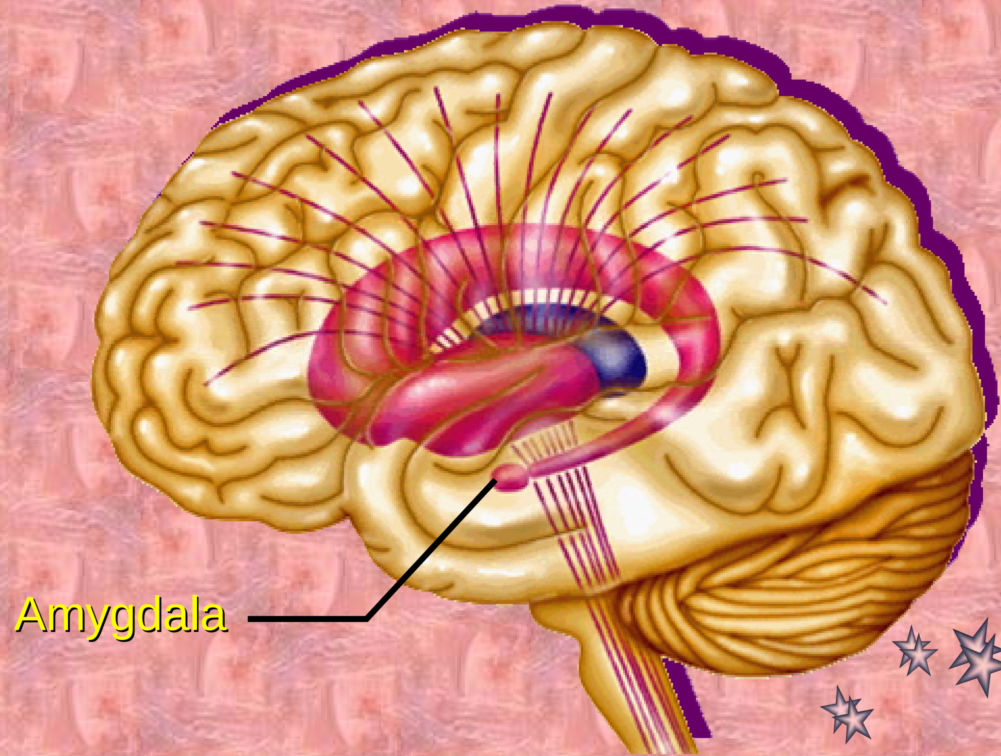
Lesions of the Basal Ganglia

Parkinson's disease,

- results from the slow and steady loss of dopaminergic neurons in Substantia nigra pars compacta (SNpc).
- The three symptoms usually associated with Parkinson's are tremor, rigidity, and bradykinesia.
  - The tremor is most apparent at rest.
  - Rigidity is a result of simultaneous contraction of flexors and extensors, which tends to lock up the limbs.
  - Bradykinesia, or "slow movement", is a difficulty initiating voluntary movement, as though the brake cannot be released.

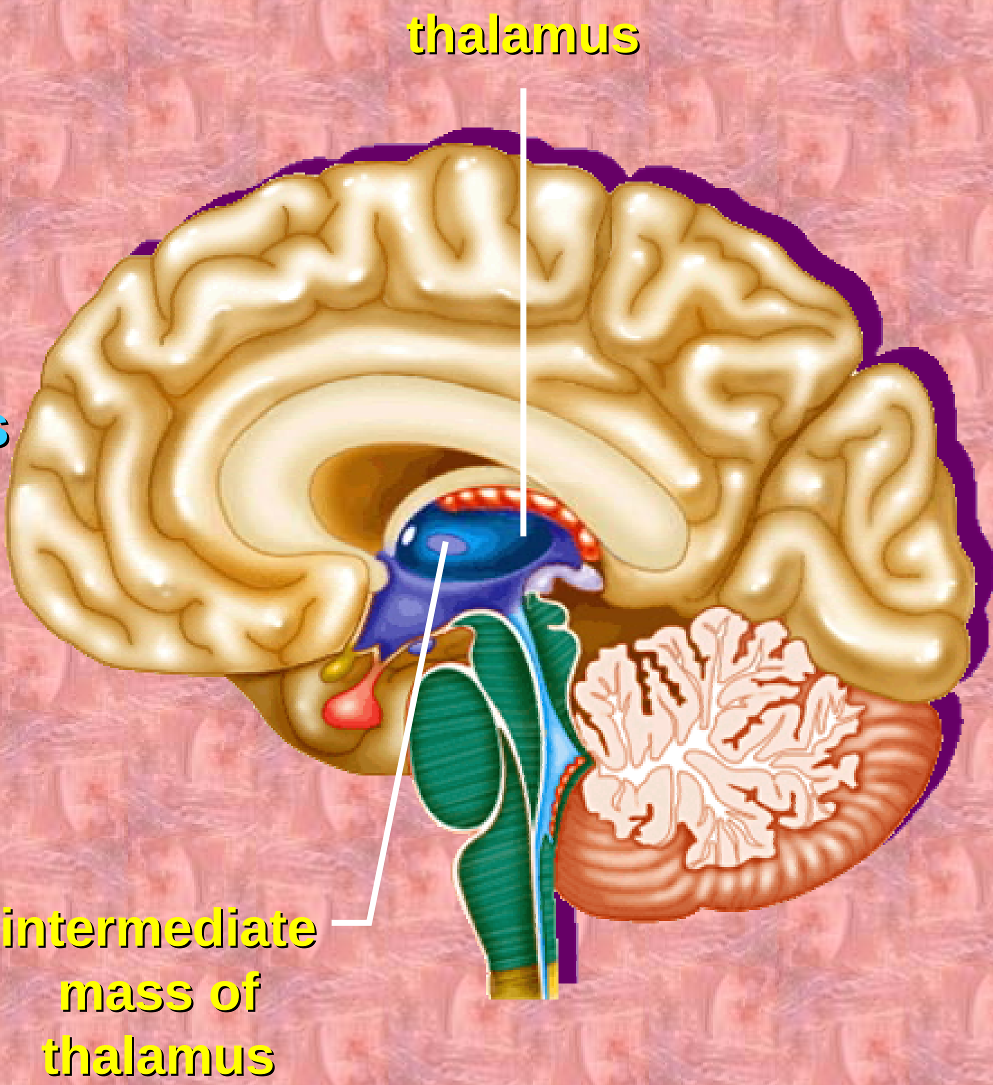
Amygdaloid nucleus

- at the tail end of the caudate nucleus; involved with reactions to reward and pleasure, sexual activities, tonic movements like raising your head.



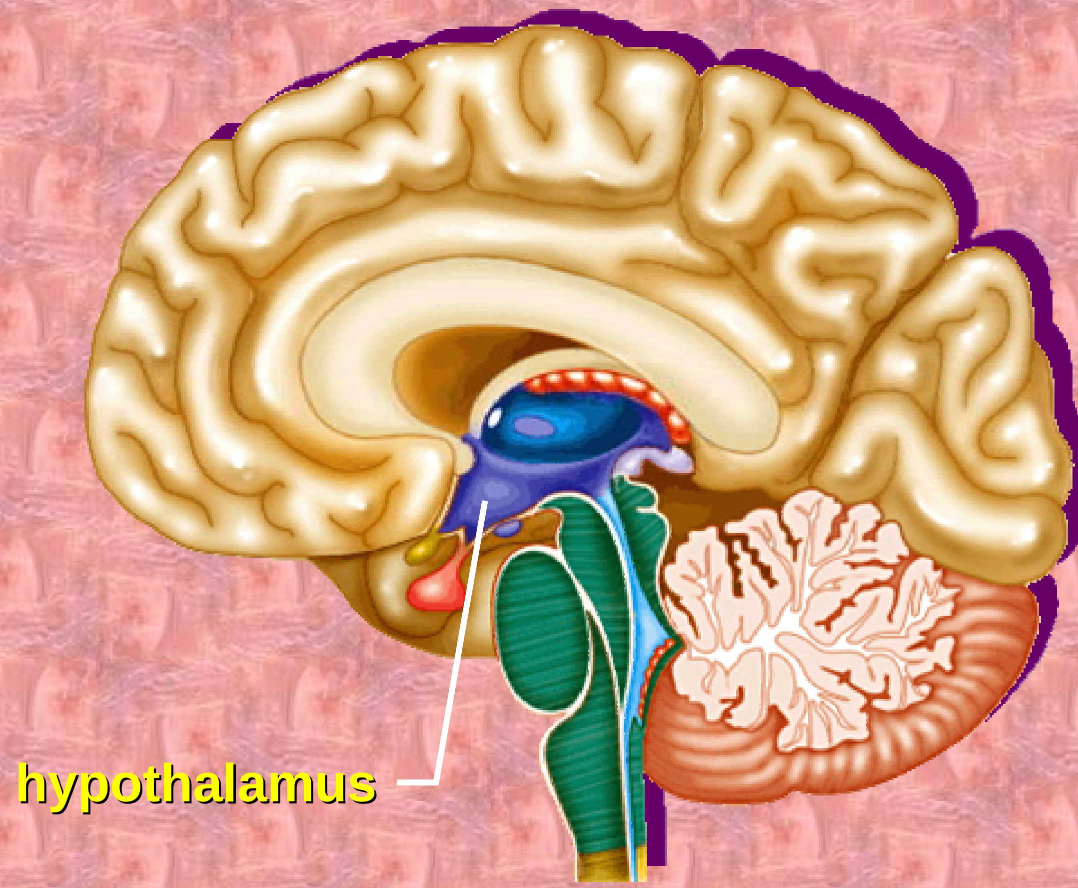
Diencephalon

- Consists of the Thalamus, Hypothalamus and Epithalamus
  - Thalamus
    - Makes up 80% of the diencephalon
    - Two large gray masses connected by the intermediate mass
    - Contains many nuclei
    - Projects fibers to and from the cortex
    - Sorts and edits info. headed for the cortex
    - Directs info. to proper cortical region



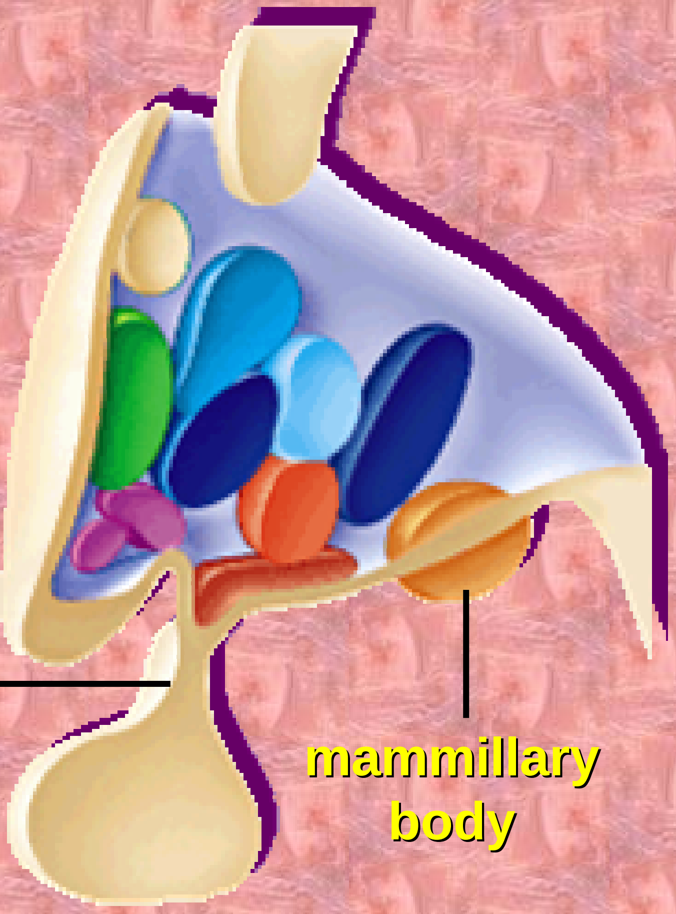
The Diencephalon

- **Hypothalamus**
  - Initiates physical expression of emotions (linked to the limbic system)
  - Regulates thirst, food intake, body temp., sexual behavior, pleasant and painful feelings, pleasure, fear, rage
  - Regulates autonomic centers in the brain stem controlling B.P., digestive rate, respiration rate



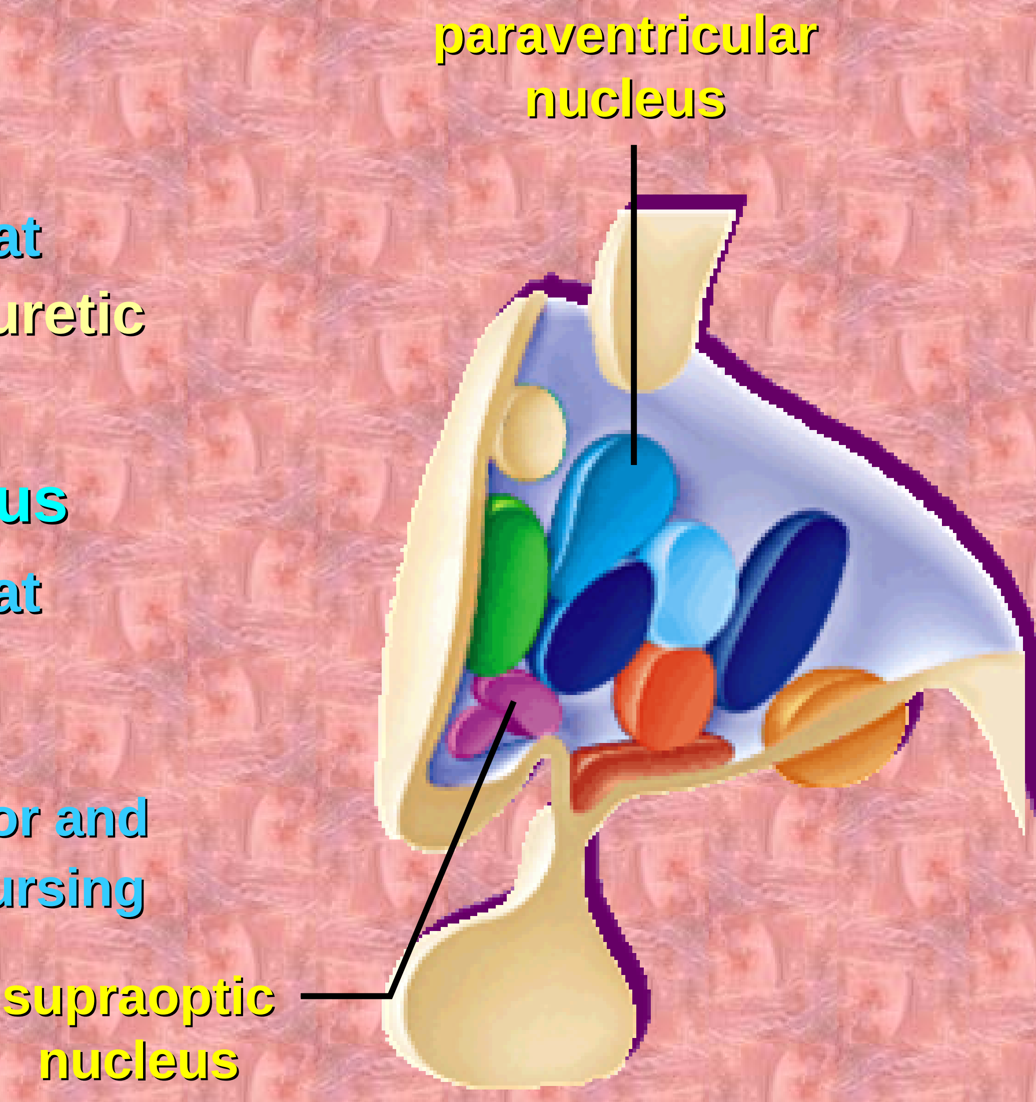
The Diencephalon

- Hypothalamus
  - Infundibulum
    - Stalk connecting the hypothalamus to the pituitary gland
  - Mammillary bodies
    - Relay station for olfactory pathways



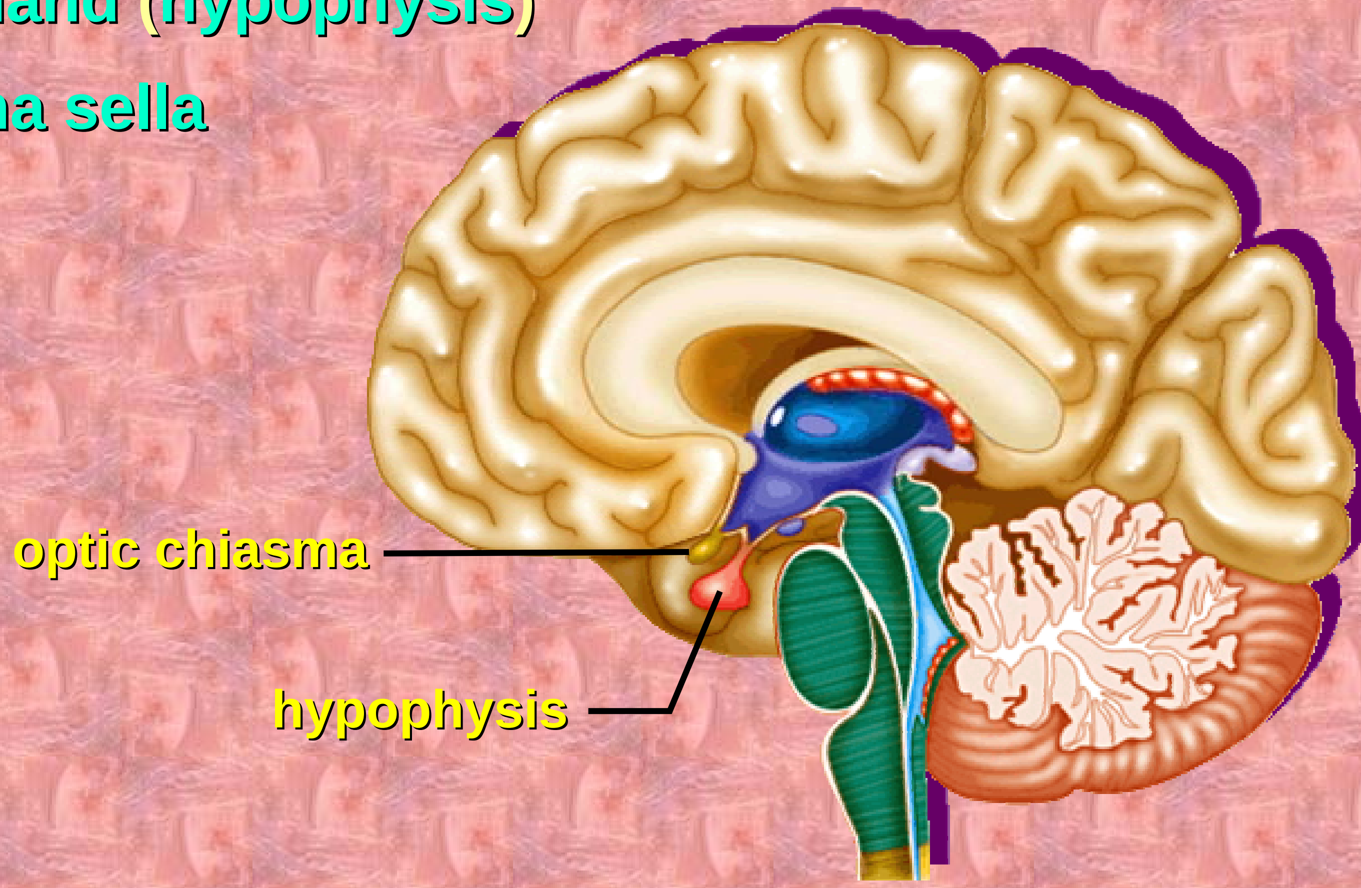
The Diencephalon

- **Hypothalamus**
  - **Supraoptic Nucleus**
    - **Contains neurons that produce ADH (antidiuretic hormone)**
  - **Paraventricular Nucleus**
    - **Contains neurons that produce oxytocin**
      - **Stimulates uterine contractions in labor and milk ejection for nursing**



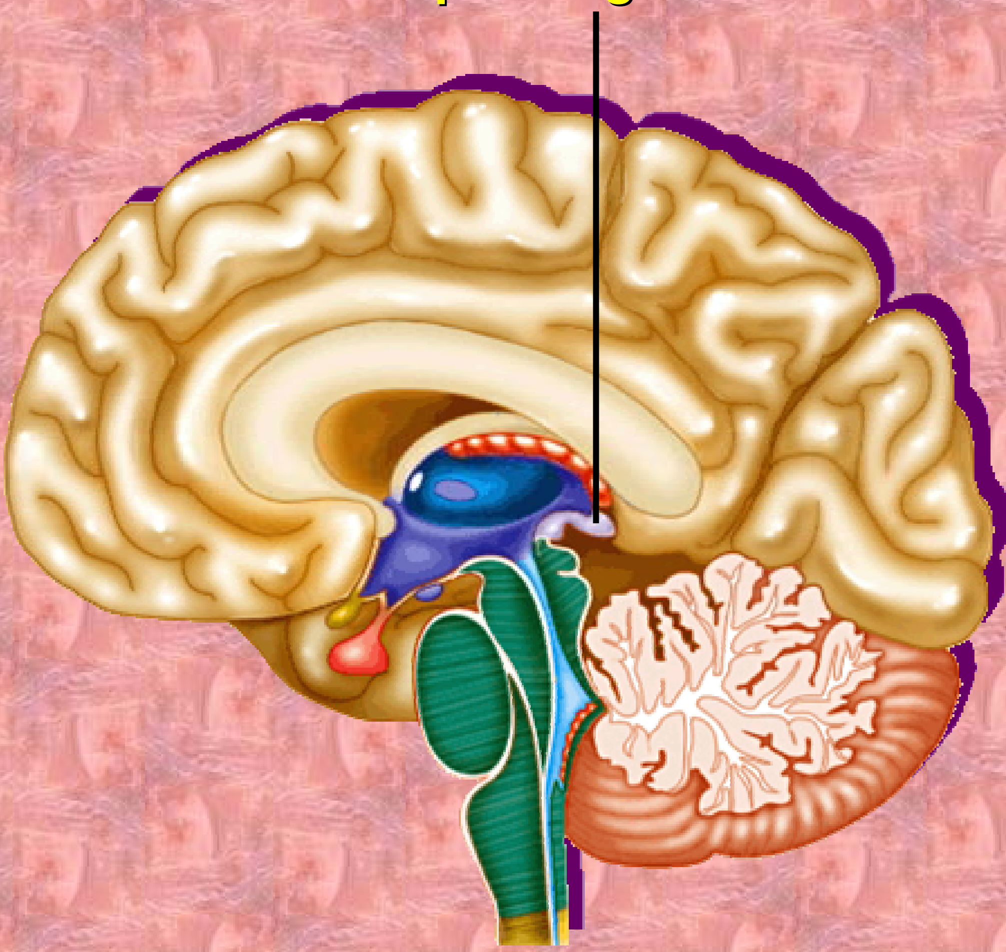
The Diencephalon

- Other structures in the region
  - Optic chiasma
  - Pituitary gland (hypophysis)
  - Diaphragma sella



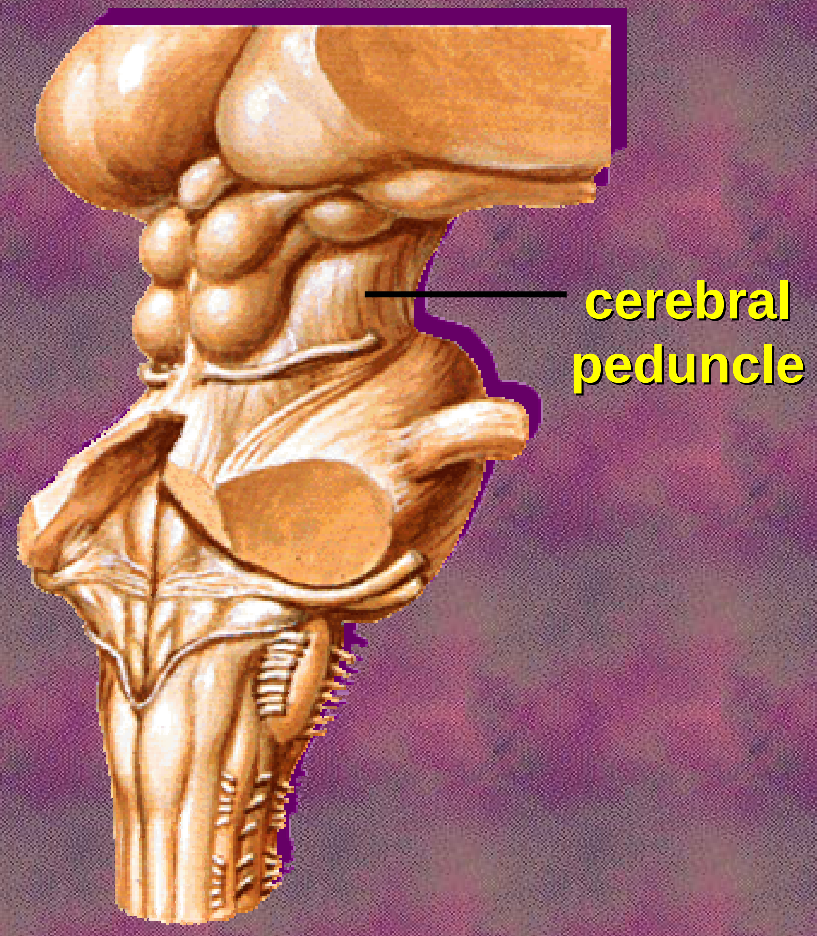
The Diencephalon

- **Epithalamus**
  - **Pineal gland**
    - **Secretes melatonin**
    - **Helps regulate sleep/wake cycles**
    - **May be influenced by light (intensity and day length)**



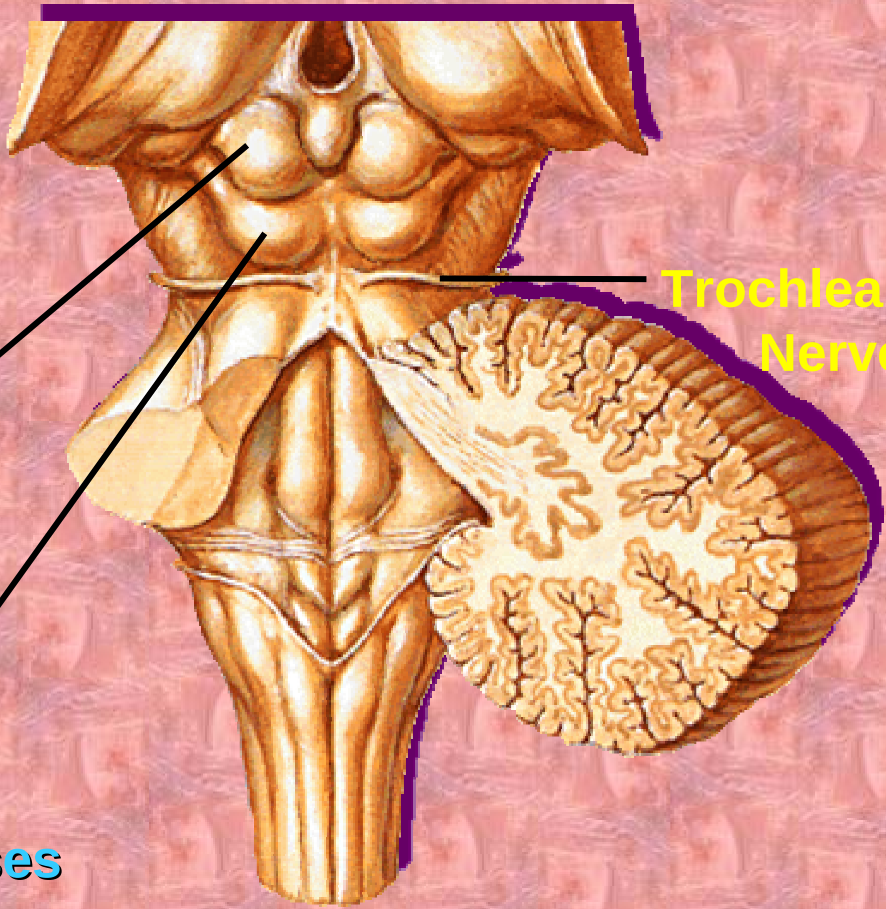
The Midbrain

- **Cerebral Aqueduct**
  - **Runs through midbrain from 3rd to 4th ventricle**
- **Cerebral Peduncles**
  - **Stalks**
  - **Contain motor fibers coming from the motor cortex (corticospinal tract)**



The Midbrain

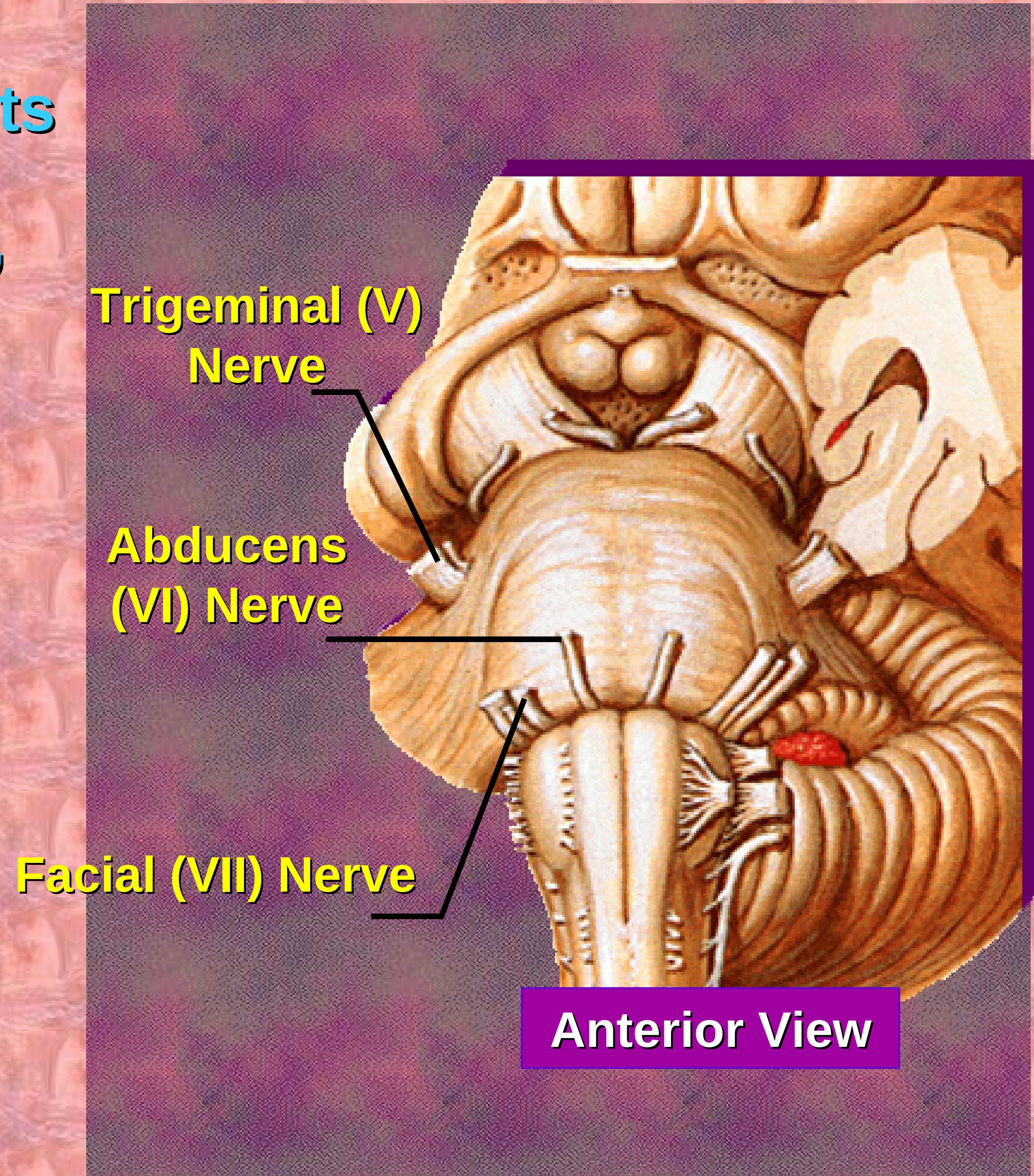
- Cranial Nerves III and IV
- Corpora Quadrigemina
  - Four dome-shaped nuclei on the dorsal midbrain
  - Superior colliculi
    - Visual reflex centers
    - Coordinate head and eye movements
  - Inferior colliculi
    - Act in reflexive responses to sound



Posterior View

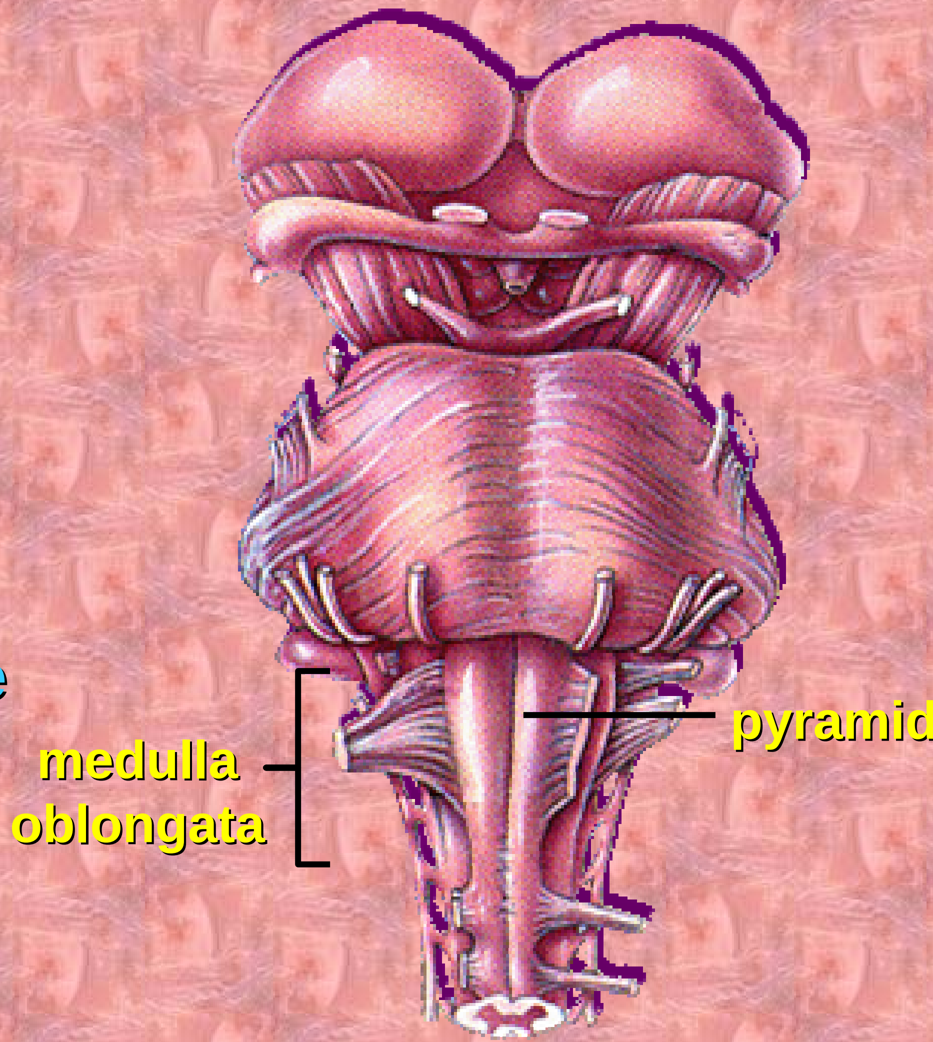
The Pons

- Mostly contains tracts
- Cranial nerves V, VI, and VII



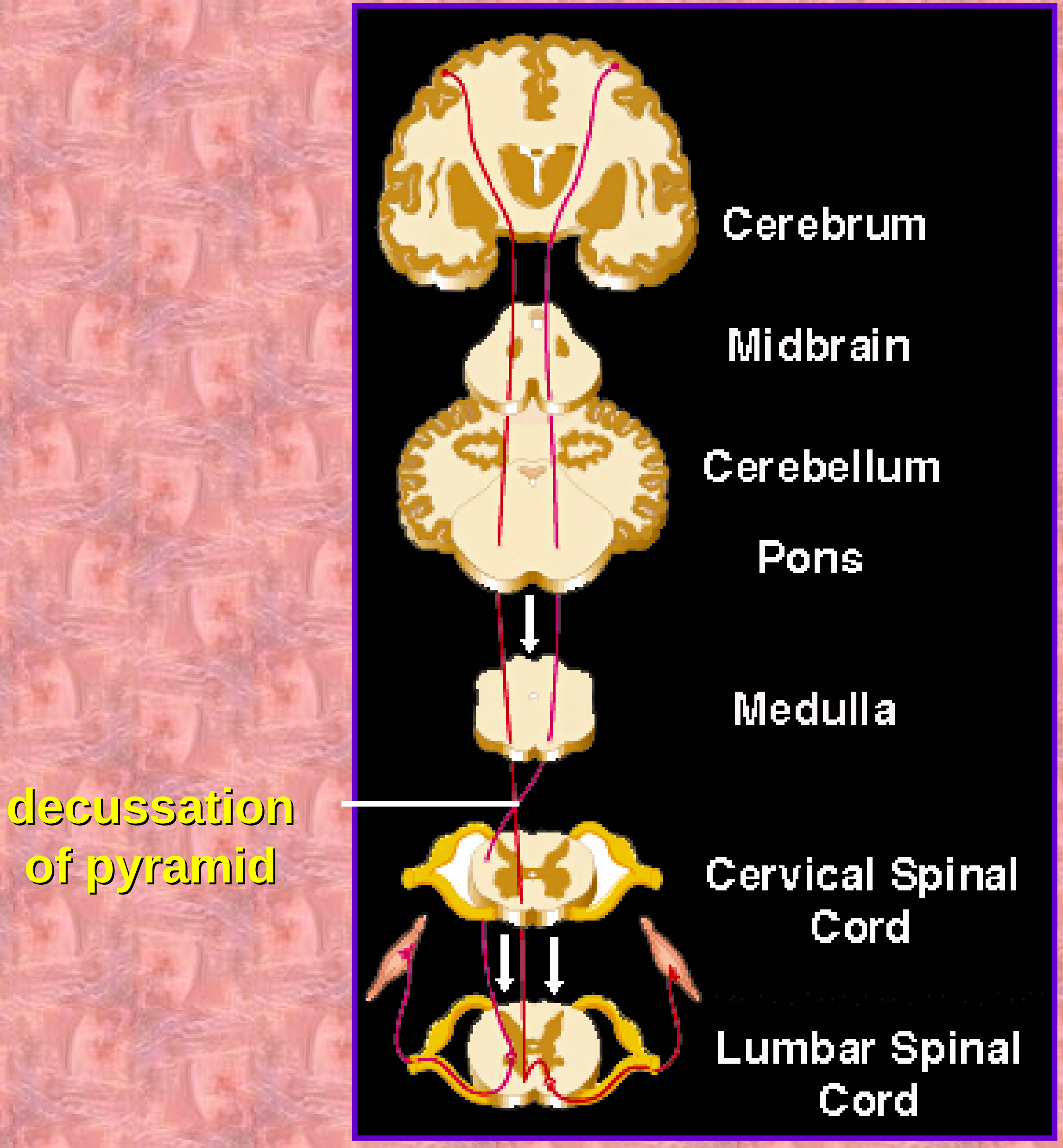
Medulla Oblongata

- **Pyramids**
  - Anterior bulges containing white matter
  - Carry corticospinal tracts running from motor cortex (voluntary muscle movement)
  - These fibers decussate (cross over) in the lower medulla = decussation of pyramids



Anterior View

Medulla: Decussation



Medulla Oblongata

- Plays a role as an autonomic relay center
- Contains several visceral motor nuclei:
  - **Cardiovascular Center**
    - Cardiac center- force and rate of heart contraction
    - Vasomotor center regulates B.P.

    -changes diameter of blood vessel walls
  - **Respiratory Centers**
    - Control rate and depth of breathing (works with pons)
  - **Other Centers**
    - Regulate activities such as hiccuping, vomiting, swallowing, coughing, sneezing

Medulla Oblongata

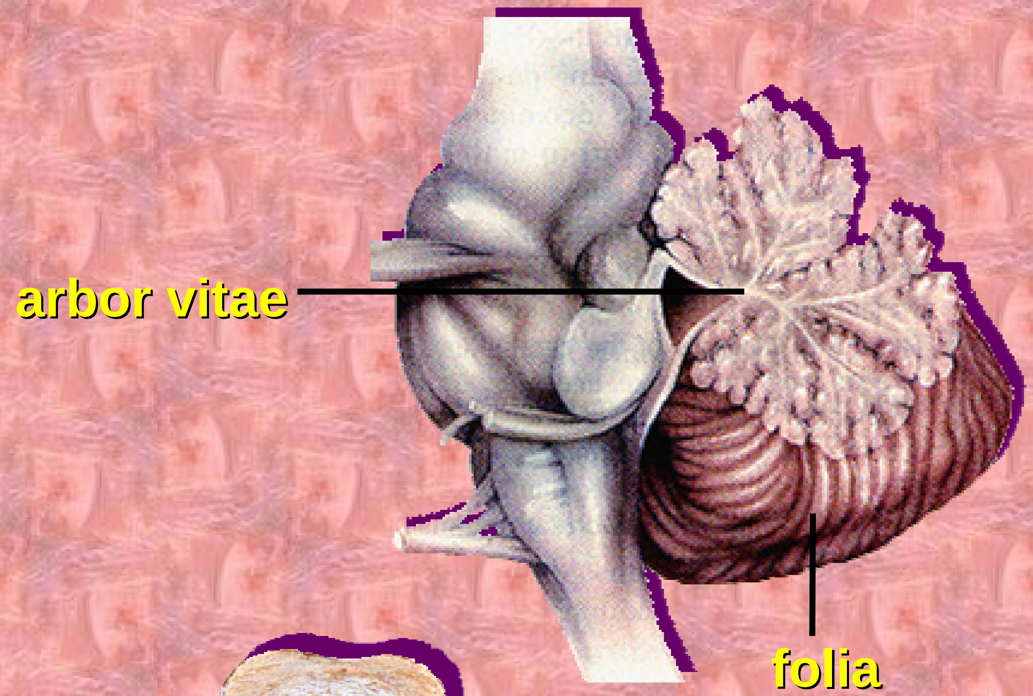
- **Ascending Sensory Tract Nuclei**
  - **Nucleus cuneatus**
    - **Relay nuclei for ascending sensory information**
  - **Nucleus gracilis**
    - **Relay sensory info. from the spinal cord up to the somatosensory cortex**
- **Olivary Nuclei**
  - **Neuron cell bodies that relay info. regarding stretch of muscles and joints to the cerebellum**

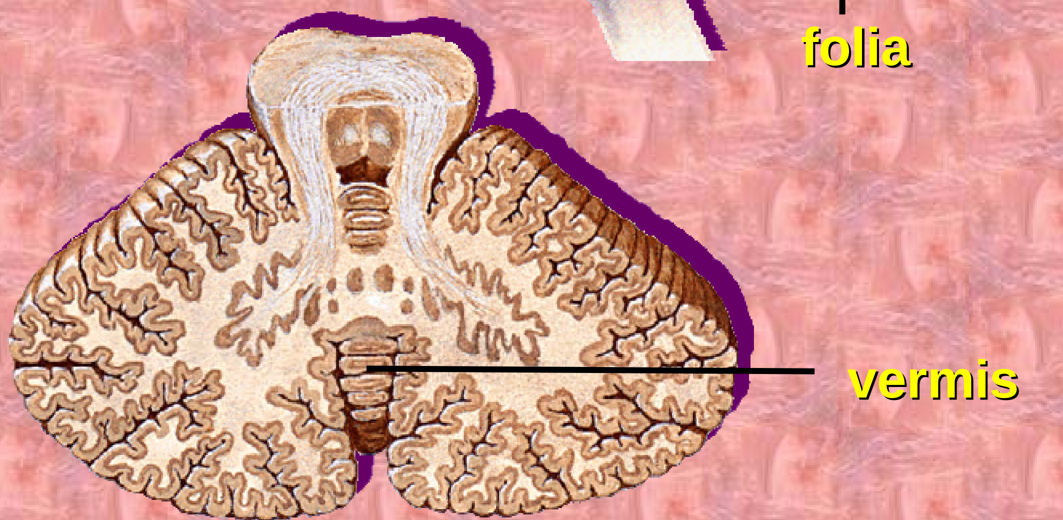
Medulla Oblongata

- C.N. VIII, IX, X, XI and XII
- Reticular Formation
  - Clusters of neuron cell bodies scattered throughout the white matter of the midbrain, pons and medulla
  - Project to the hypothalamus, thalamus, cerebellum and spinal cord
  - Govern arousal of the brain by sending continuous impulses to the cerebral cortex to keep it alert (RAS)
  - Filters out repetitive or weak signals to dampen unnecessary input

The Cerebellum

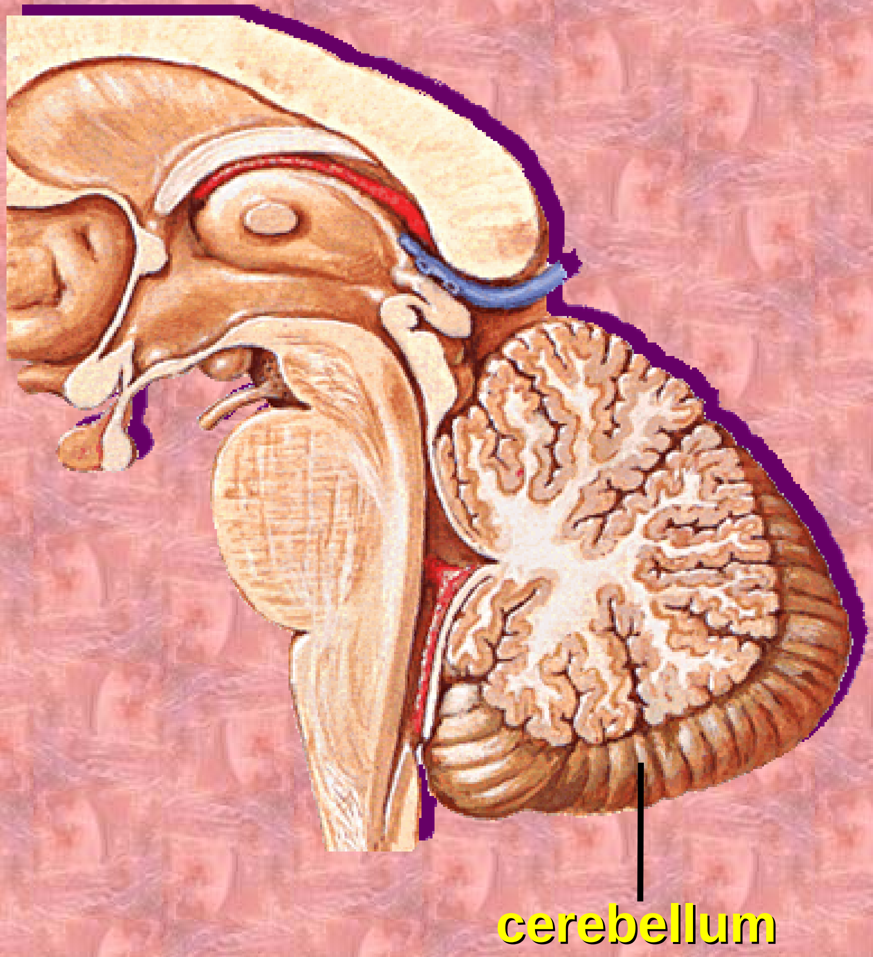
- Two hemispheres
  - Separated by the **falx cerebelli**
- Vermis
  - Worm-like structure between the 2 hemishperes
- Folia and fissures
  - Similar to gyri and sulci
- Arbor vitae
  - White matter with a tree- like appearance





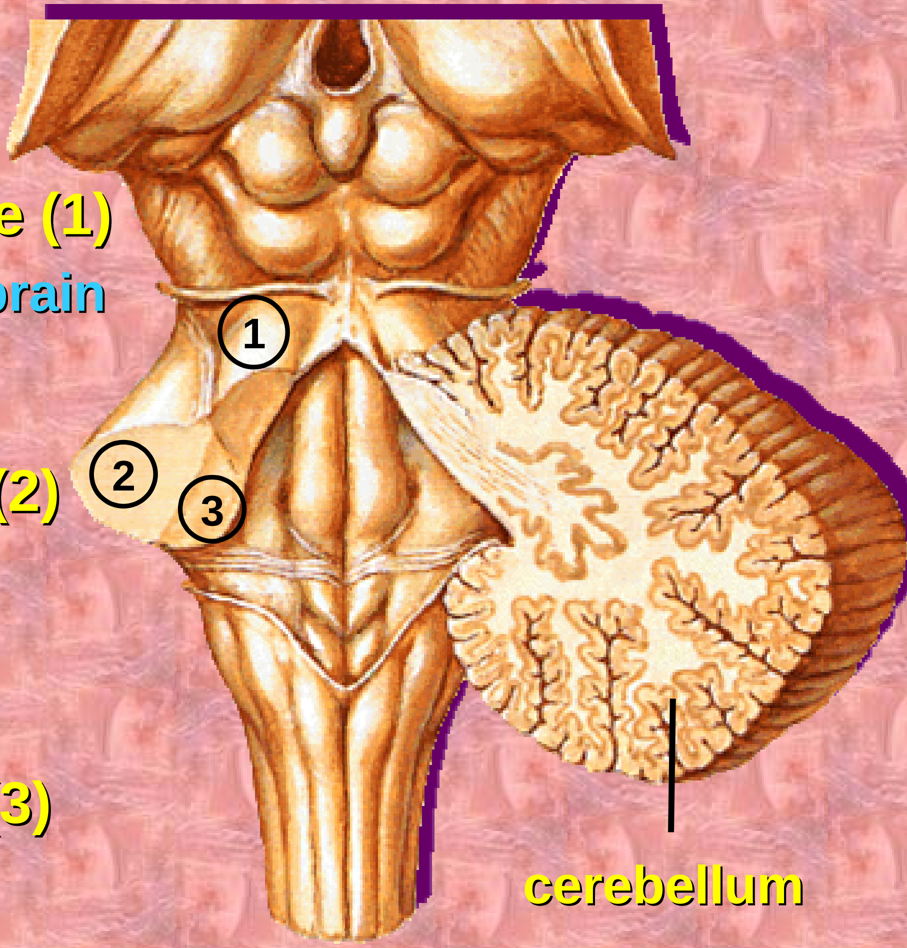
Cerebellum

- **Function**
  - Processes info. from the cerebral motor cortex, brainstem nuclei and sensory receptors
  - Sends output regarding timing and coordination of skeletal muscle contraction
  - Makes movements smooth and coordinated



The Cerebellum

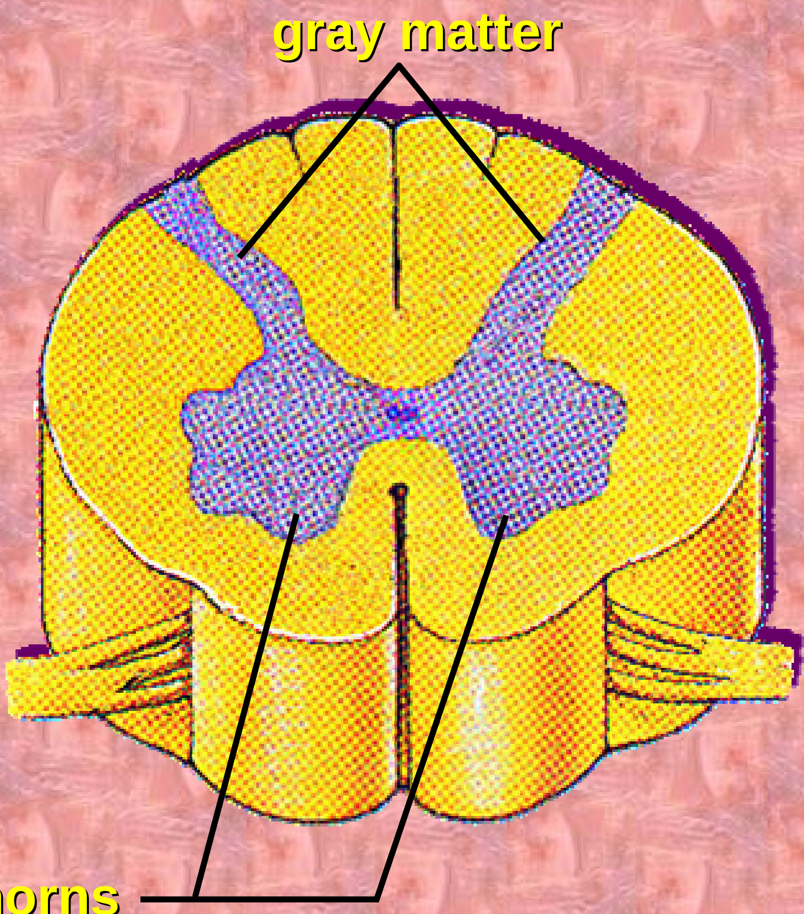
- **3 Cerebellar Peduncles**
  - **Connect the cerebellum to the brainstem**
  - **Superior Cerebellar Peduncle (1)**
    - **Carries axons between midbrain and cerebellum**
  - **Middle Cerebellar Peduncle (2)**
    - **Carries axons between the pons and cerebellum**
  - **Inferior Cerebellar Peduncle (3)**
    - **Carries axons between the medulla and cerebellum**



Spinal Cord Structure

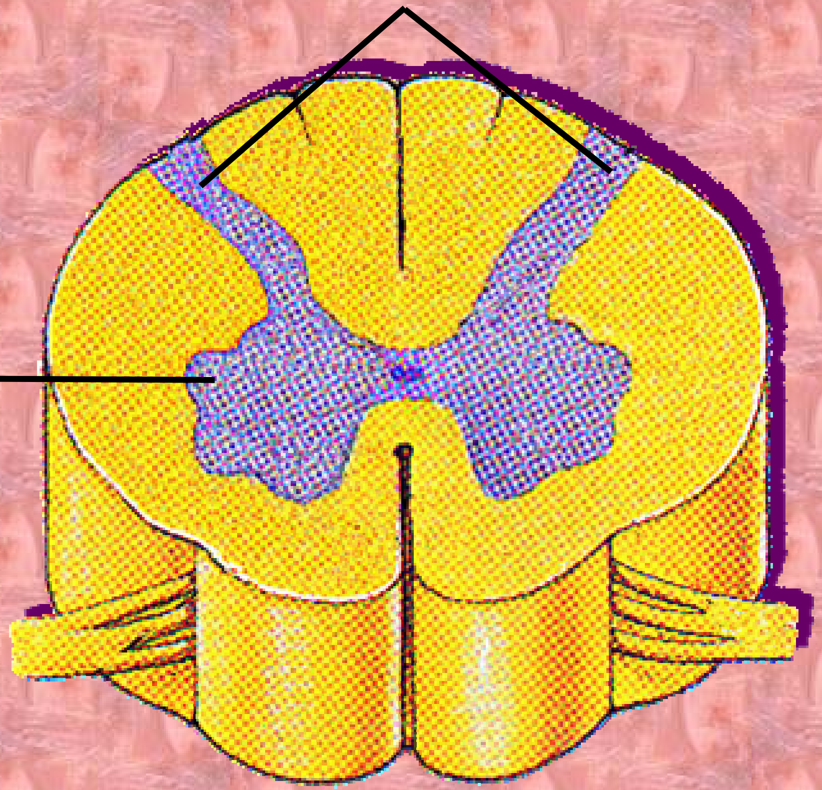
- **Gray Matter**
  - **In the interior of the cord**
  - **Forms an 'H' shape**
  - Dendrites & terminals
  - Spinal reflex integrating center

  - **Ventral Horns**
    - **Anterior projections of gray matter**
    - **Contain cell bodies of large alpha motor neurons**



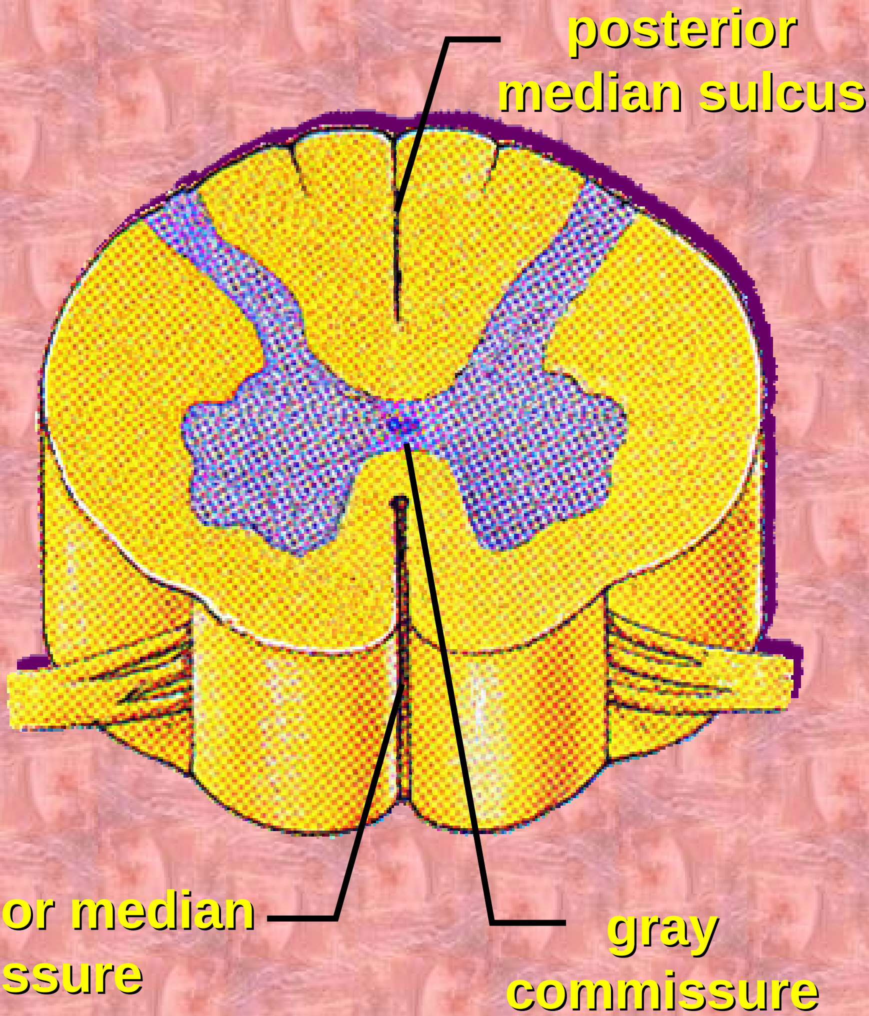
Spinal Cord: Gray Matter

- **Dorsal Horns**
  - Incoming unipolar sensory neurons enter and synapse with association neurons
  - Cell bodies of these sensory neurons are in the dorsal root ganglia
- **Lateral Horns**
  - Only visible from T_1 to L_2
  - Contain autonomic neuron cell bodies



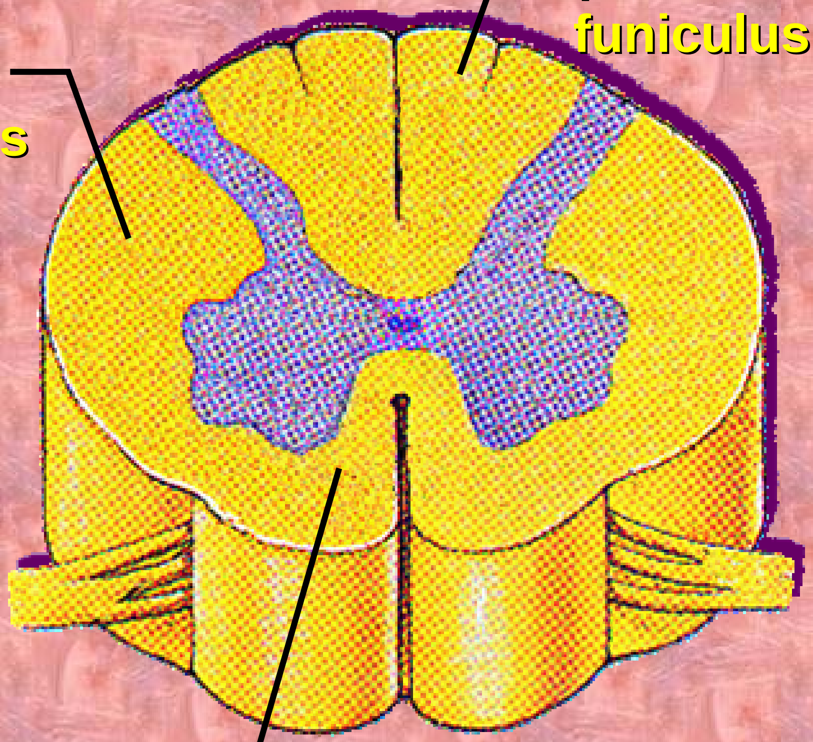
Spinal Cord: Structure

- Gray commissure
  - Connects right and left halves of gray matter
- External fissures
  - Anterior median fissure
  - Posterior median sulcus



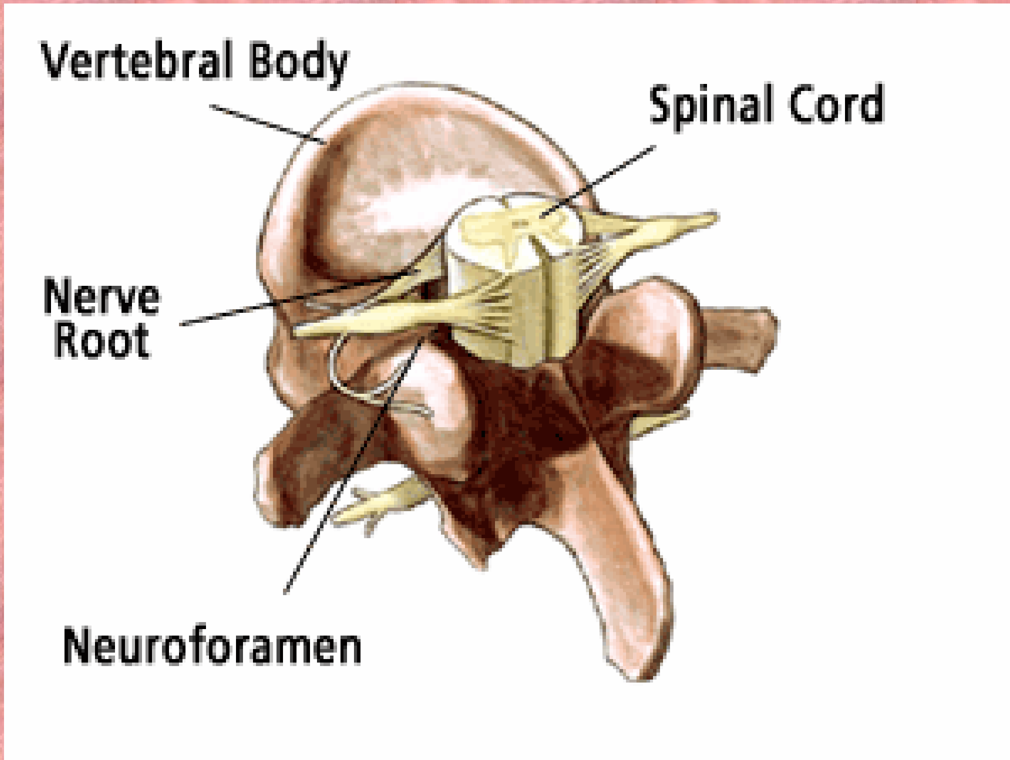
Spinal Cord: Structure

- **White matter**
  - **Divided into columns called columns or funiculi**
  - **Anterior, lateral and dorsal white columns or funiculi**



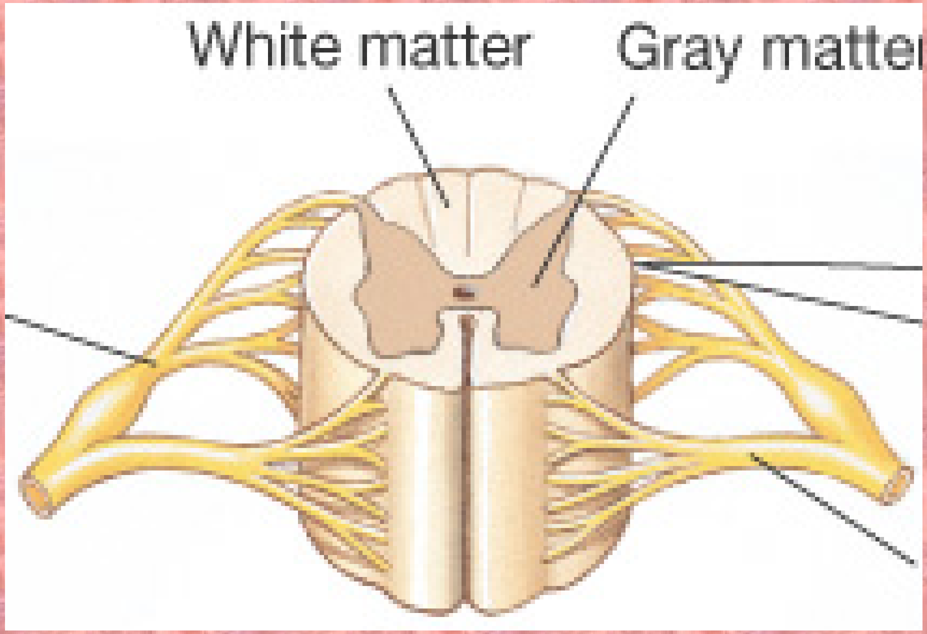
Spinal Cord: Structure

- Rootlets branch off nearly continuously amd coalesce into about 31 discrete nerves along the cord (8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 coccygeal nerves).



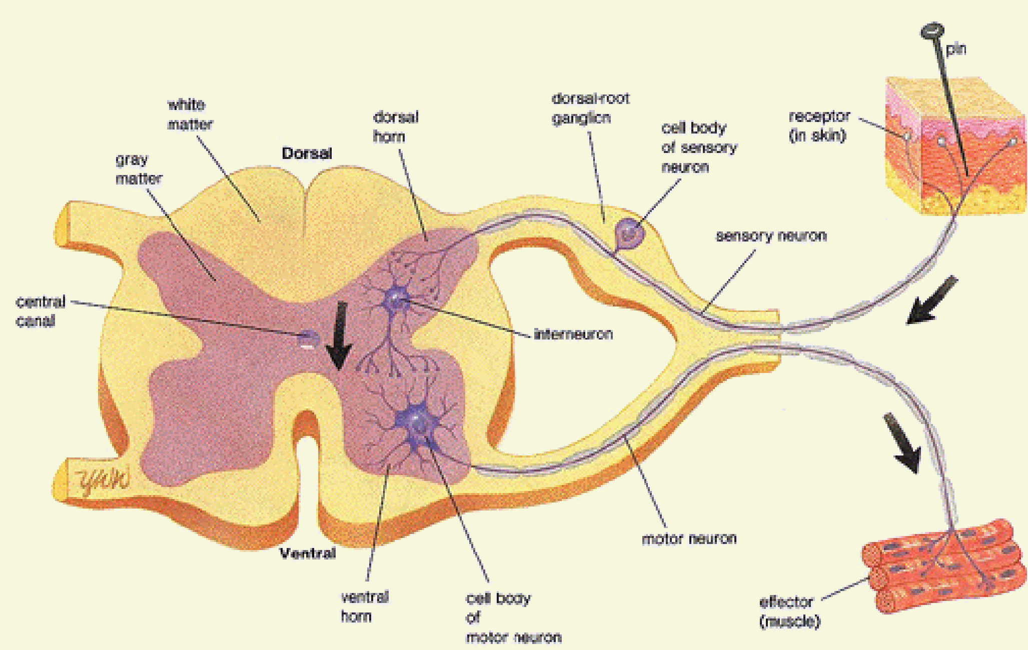
Spinal Cord: Structure

- At each segment, rootlets appear to come out of both the dorsal and ventral halves of the spinal cord,
  - Dorsal roots- going into the cord
  - Ventral roots- coming out of the of the cord



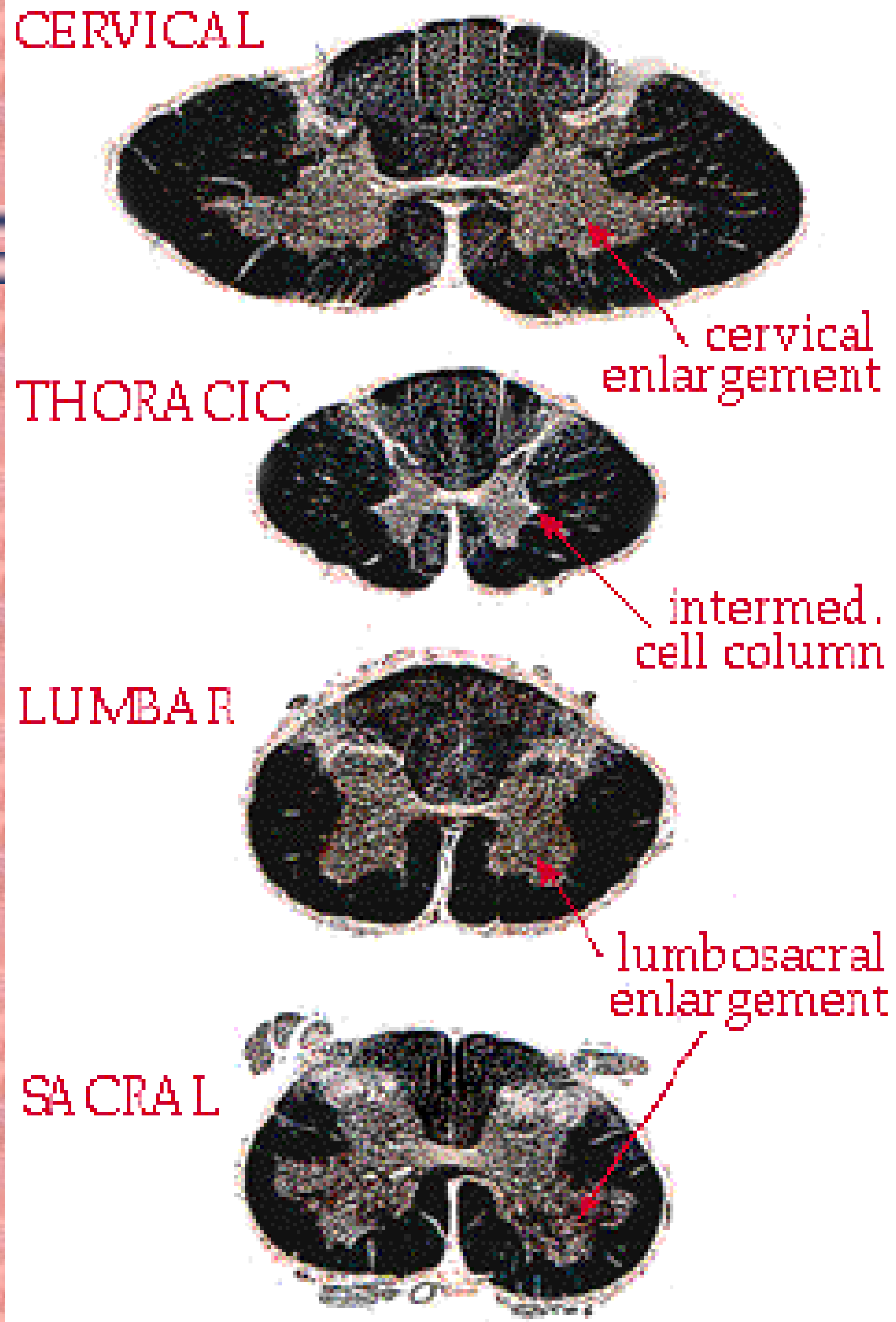
Spinal Cord: Structure

- Along the dorsal root is a collection of cell bodies called the <u>dorsal root ganglion.</u>
- Inside the ganglion are the cell bodies of all the receptor neurons that send processes out to the periphery.
  - The free nerve ending in the tip of your finger that feels the paper cut actually has its cell body back in the dorsal root ganglion.



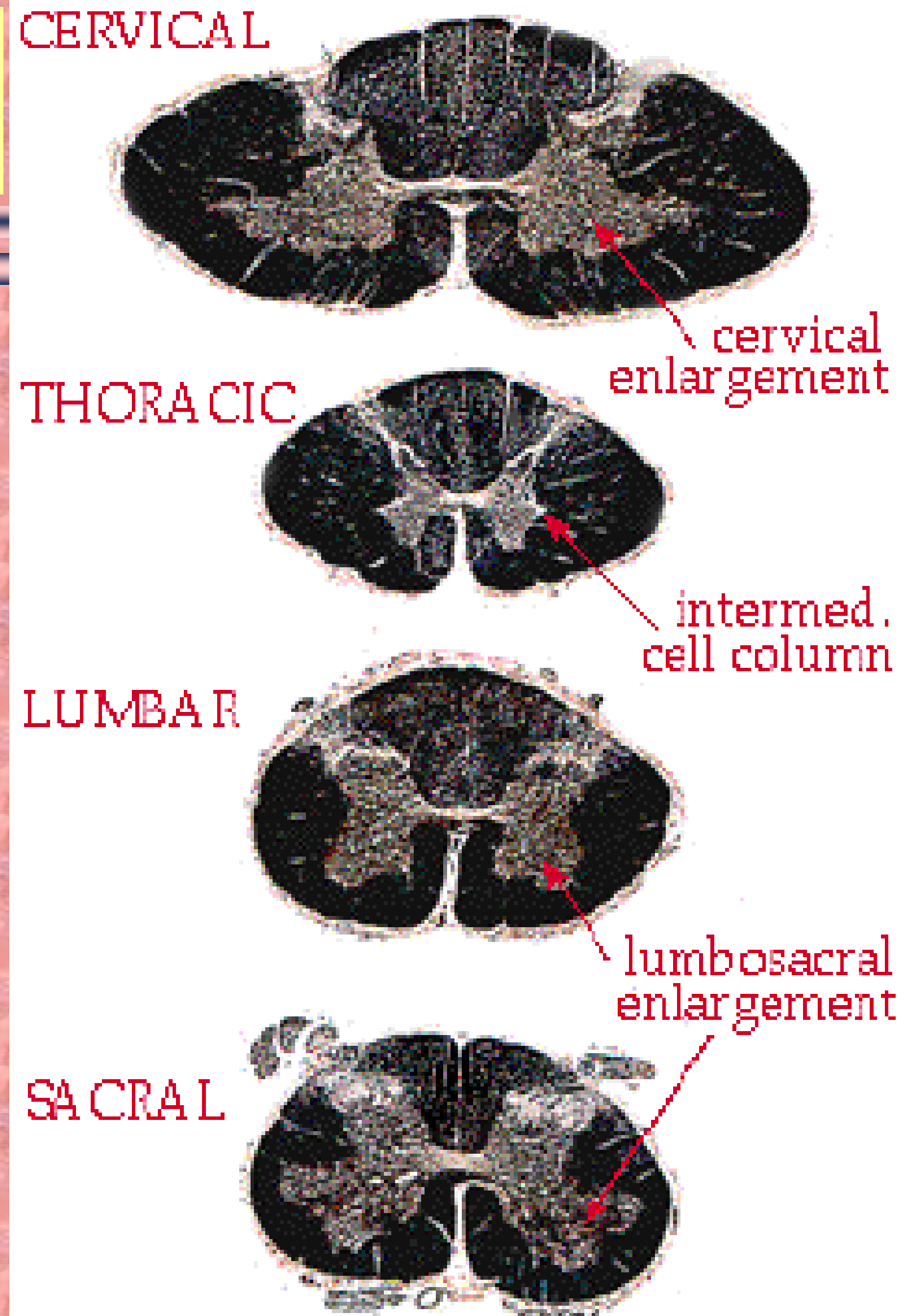
Differentiating Levels of the Cord

- Overall shape
  - Cervical sections tend to be wide and squashed looking, like an oval.
  - Compare the cervical section to the round lumbar section.



Differentiating Levels of the Cord

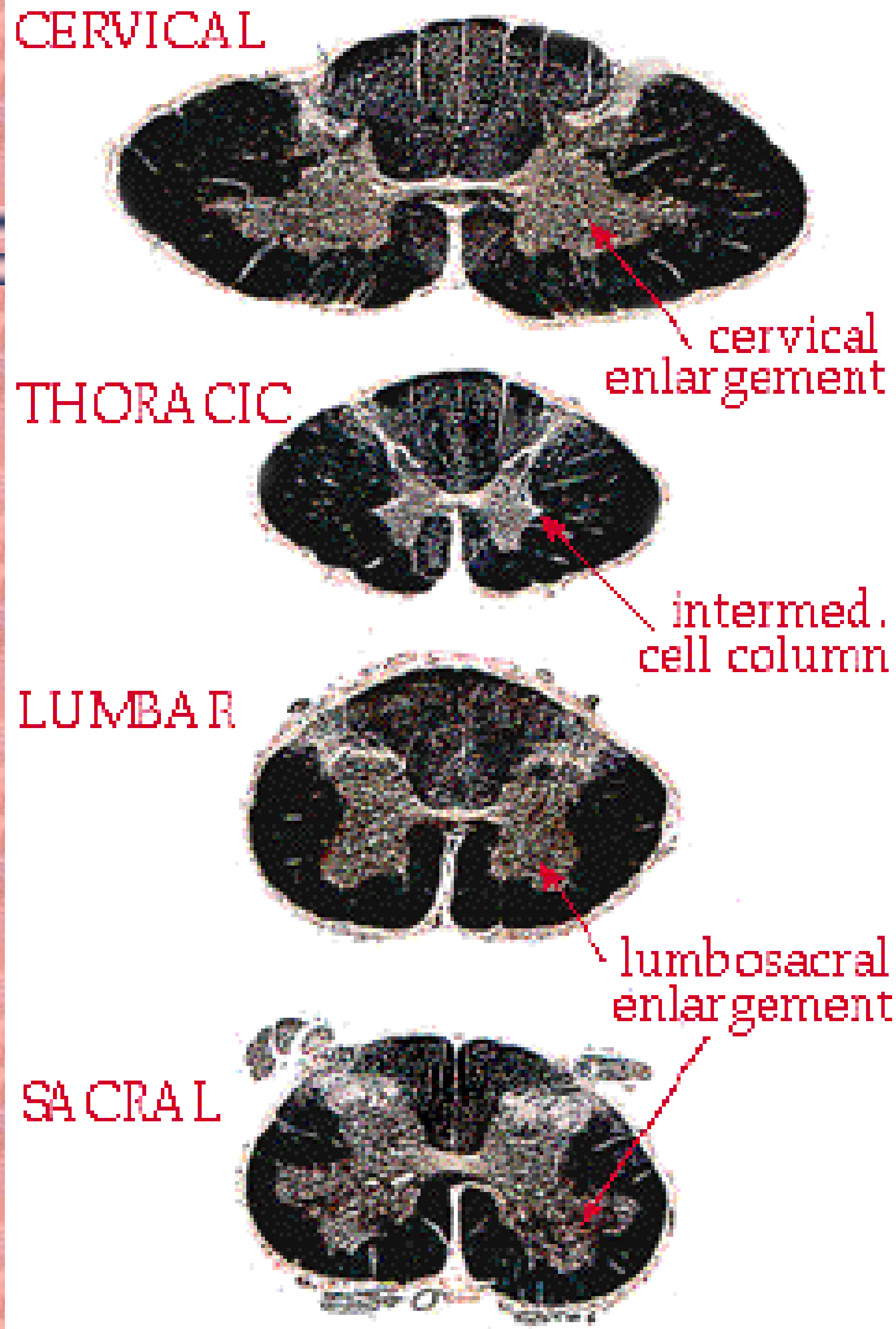
- Ventral horn enlargement
  - At segments that control a limb, the motor neurons are large and numerous.
  - This causes enlarged ventral horns in two places: the lower cervical sections (C5-C8) and the lumbar/sacral sections.



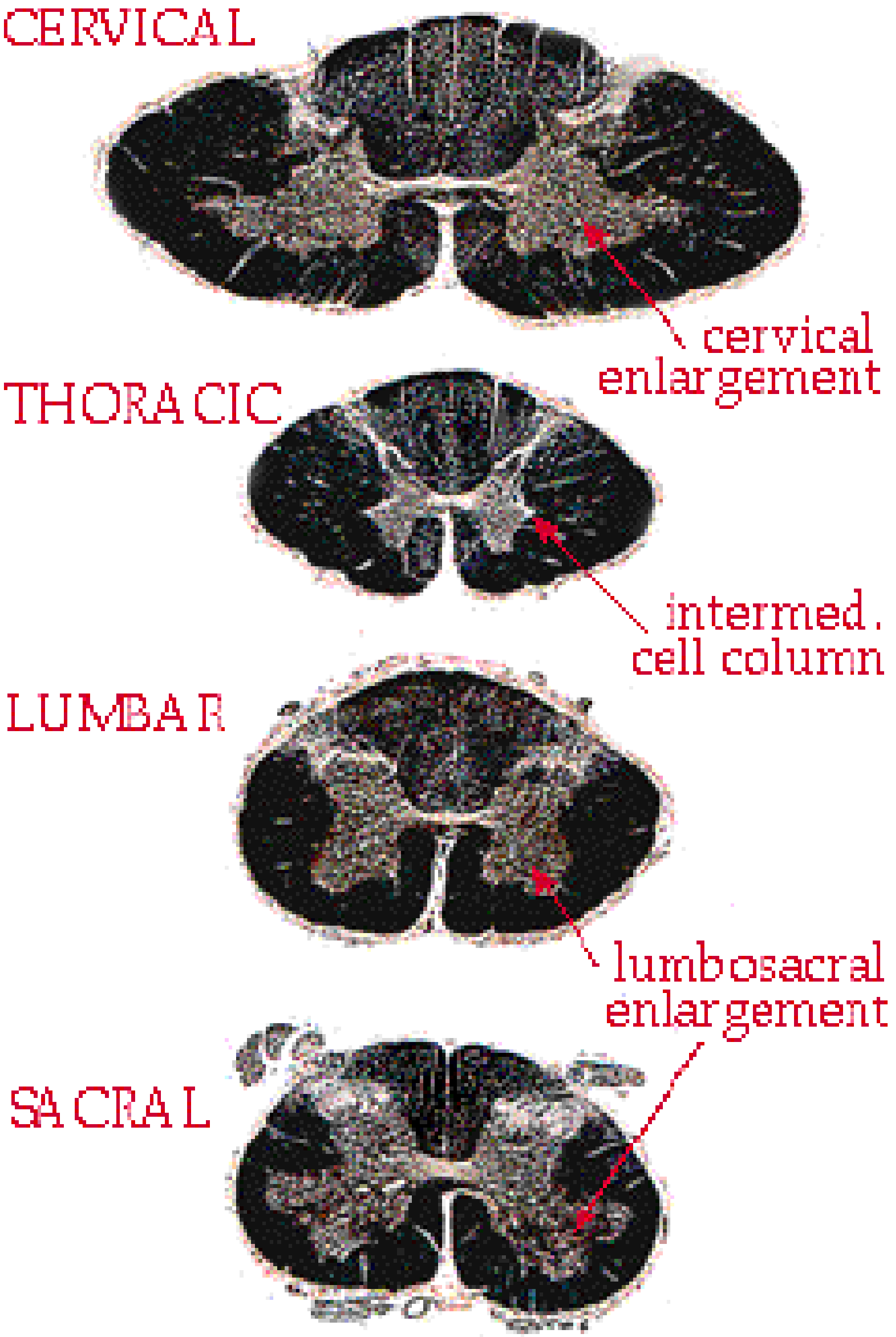
Differentiating Levels of the Cord

Proportion of white matter to gray matter

- The amount of white matter relative to grey matter decreases as you move down the cord.
  - in the white matter of the cervical cord you have all of the axons going to or from the entire body.
  - In sacral cord the white matter contains only those axons going to or from the last couple of dermatomes - all other axons have "gotten off" at higher levels.



- wide flat cord, lots of white matter, ventral horn enlargements = cervical.
- Round cord, ventral horn enlargements = lumbar.
- Small round cord, almost no white matter = sacral.
- the intermediate horn, or the intermediolateral cell column.
  - It is the source of all of the sympathetics in the body, and occurs only in thoracic sections.



Spinal Cord Tracts

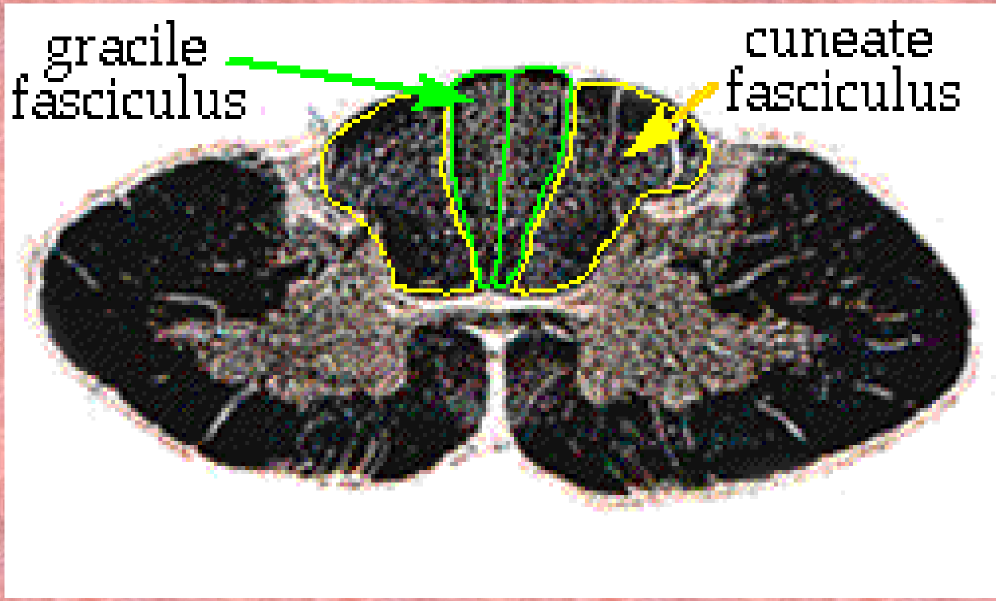
- Divided into colunms (funiculi) containing tracts
- Ascending tracts relay info from spinal cord to brain (sensory)
- Descending tracts relay info from brain to cord (motor)

Sensory (Acending) Tracts

- Fibers carry signals for vibration, visceral pain, deep and discriminative touch (touch whose location one can precisely identify) and especially proprioception (nonvisual sense of the position and movement of the body)

Sensory (Acending) Tracts

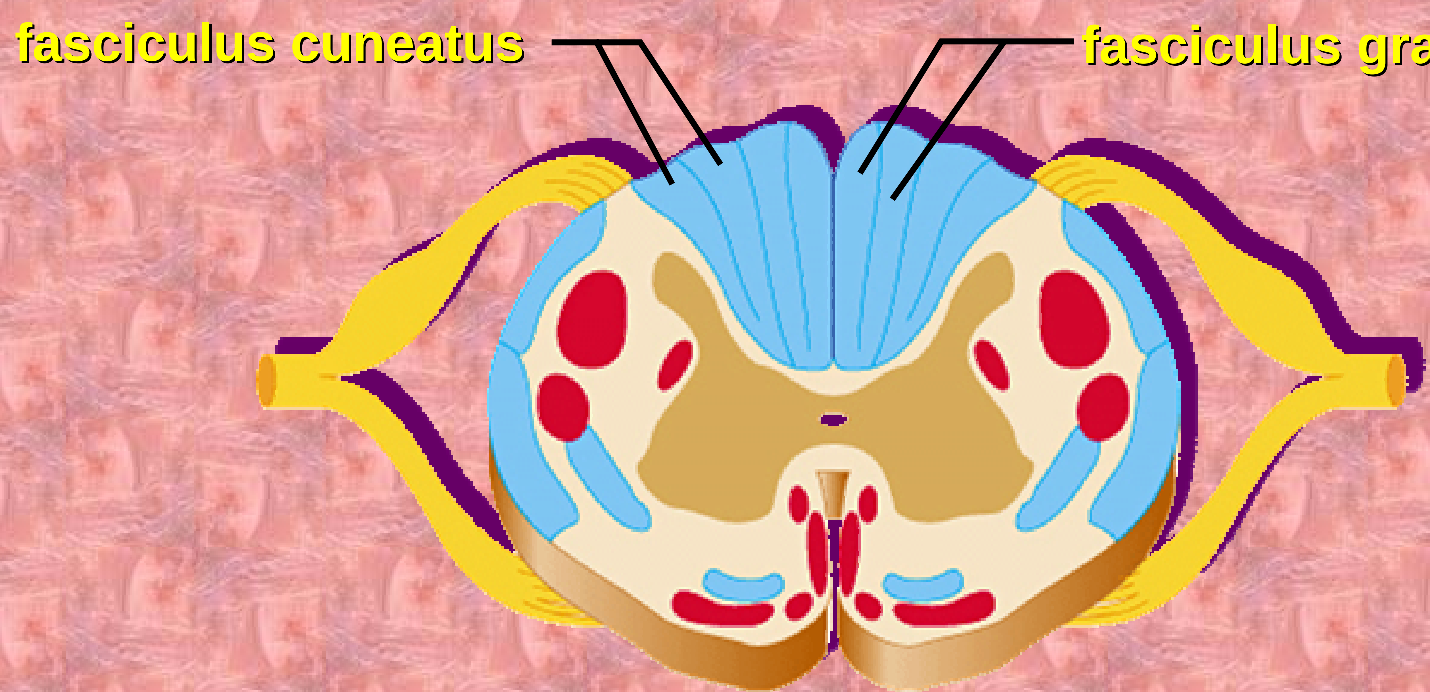
- Since the tracts are on the dorsal side of the cord, they are sometimes called the dorsal columns or posterior columns.
- the posterior columns can actually be divided into two separate tracts.
  - The midline tracts are tall and thin, and are given the name gracile fasciculus (gracile means slender, and fasciculus means a collection of axons).
  - The outer tracts are more wedge shaped, and were given the name cuneate fasciculus (cuneate means wedge-shaped).



Spinal Cord Tracts

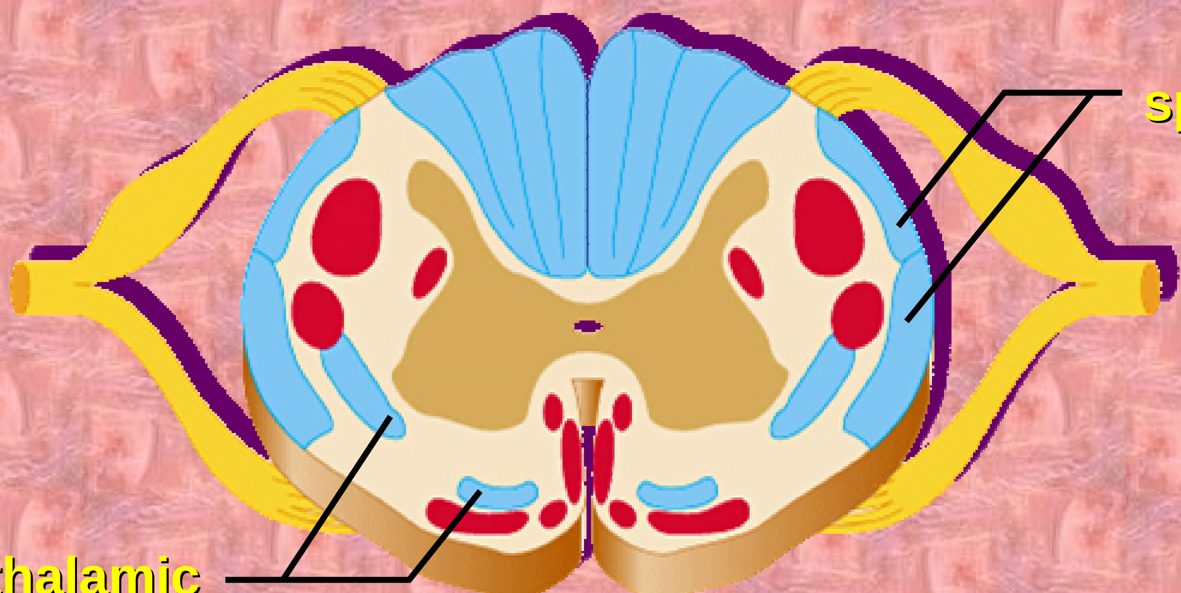
Ascending Tracts

- Carries info from skin, joints and muscles concerning discriminative touch, pressure, vibration and body position
  - **Fasciculus cuneatus**
    - The cuneate fasciculus is carrying information from the upper half of the body (T6 from the upper limb and chest).
  - **Fasciculus gracilis**
    - carrying all of the information from the lower half of the body (T6, midthoracic and below)



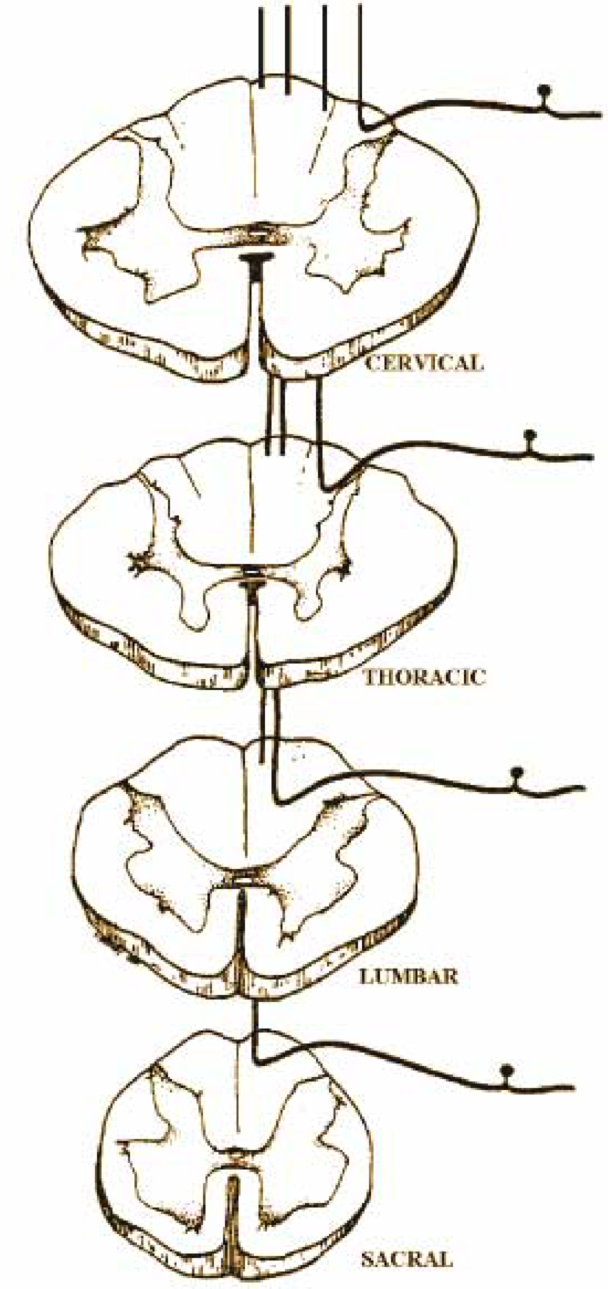
Spinal Cord Tracts

- **Ascending Tracts**
  - **Spinothalamic**
    - Ascending afferent sensory fiber tract
    - Info regarding pain, temperature and crude touch
  - **Spinocerebellar**
    - Afferent sensory tract
    - Carries info regarding movement and limb position



Somatotopic Oganization

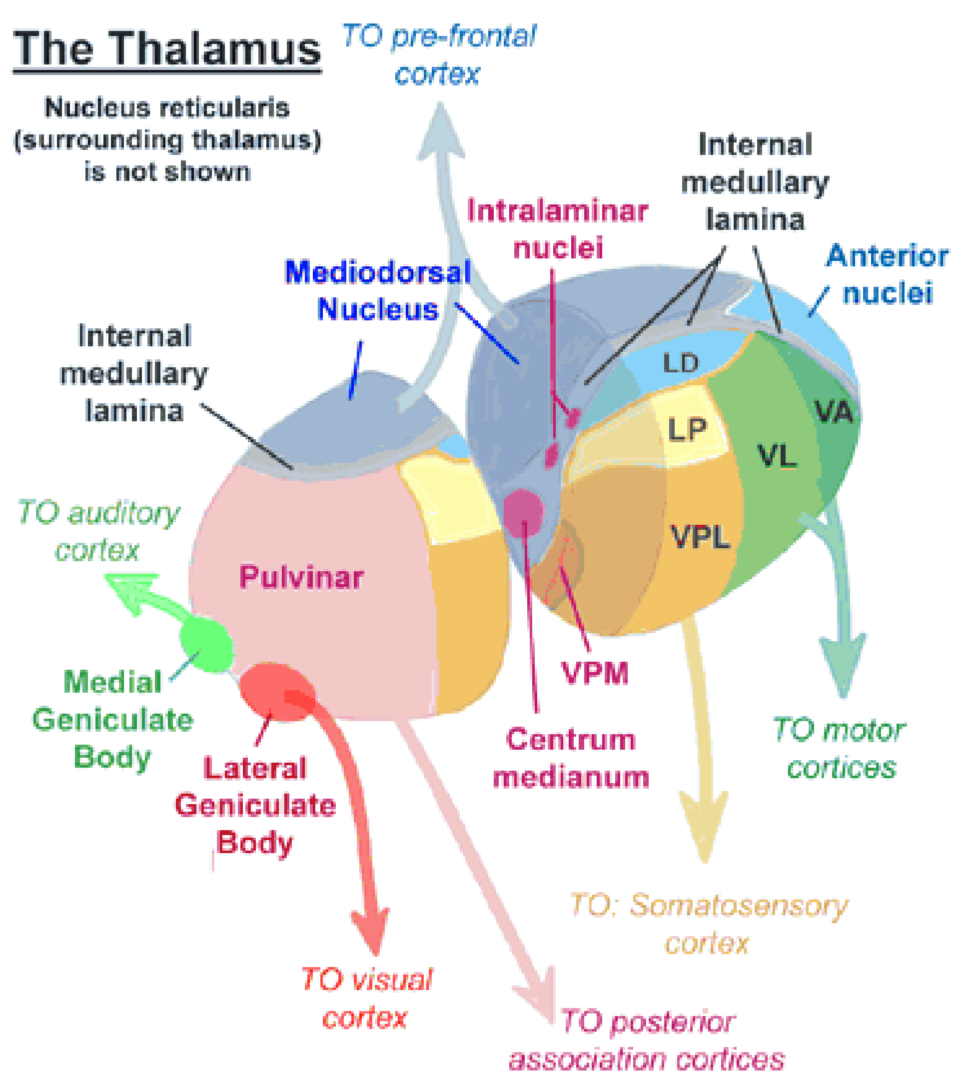
- There is a somatotopic representation of the body in the dorsal columns (fasciculus gracilis and fasciculus cuneatus).
- Caudal (sacral and lumbar) body parts are represented medially
- Rostral segments (upper thoracic and cervical) are represented laterally.
- Nucleus gracilis receives its input from about T7 and downward,
- While nucleus cuneatus receives its input from spinal levels above T7



SOMATOTOPIC ORGANIZATION
OF THE DORSAL COLUMNS

The Role of the Thalamus in Sensory Processing

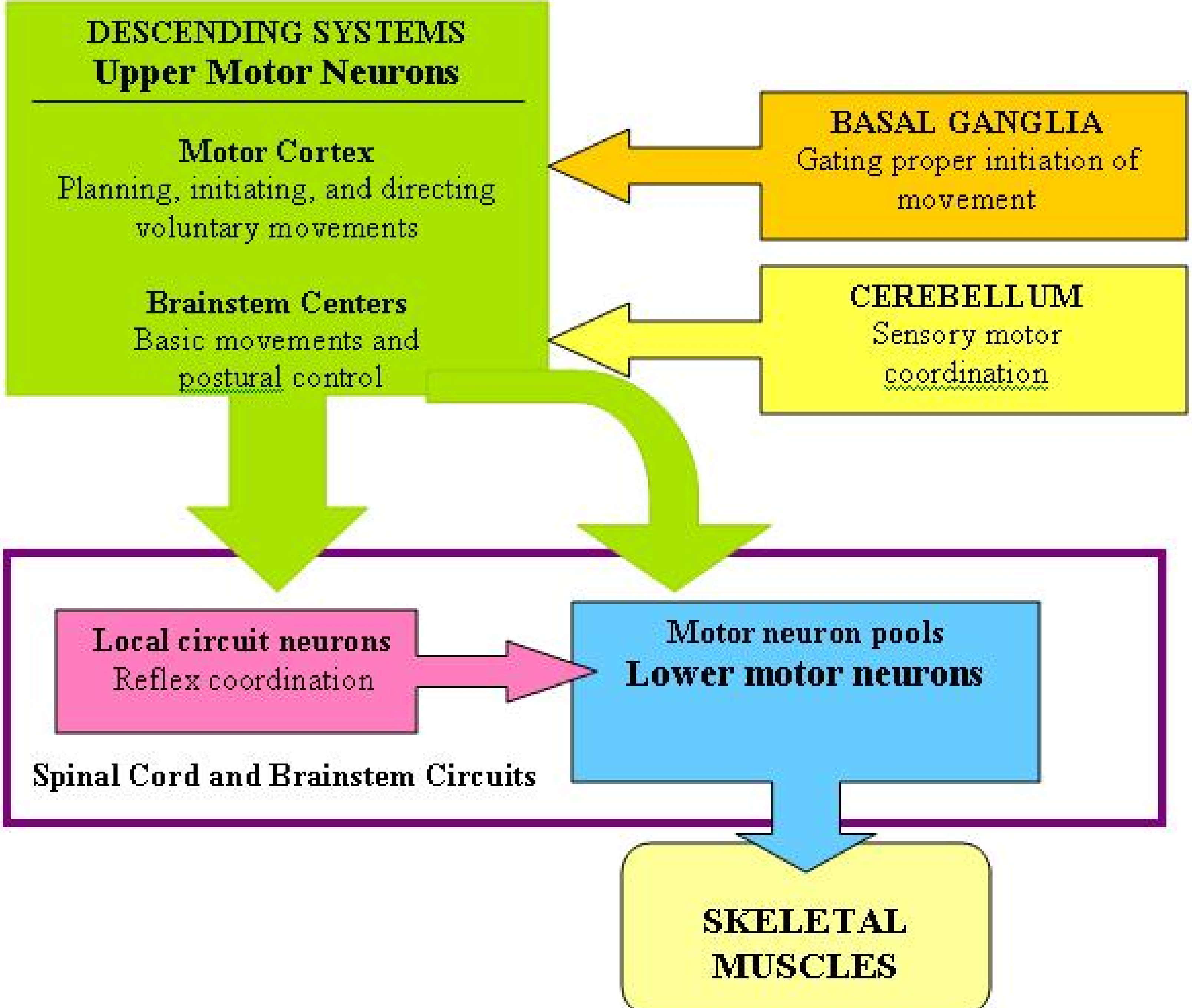
- Brain region that serves as a switching center for all sensory signals passing from the brain stem to other brain regions EXCEPT SMELL.
- There are 2 thalami, and they are located on either side of the 3rd ventricle.
- Contains many nuclei but 3 are important for sensory processing
  - the ventral posterior medial (VPM) and lateral nuclei (VPL)
  - the lateral geniculate nucleus
  - the medial geniculate nucelus.



Movement and Its Central Control

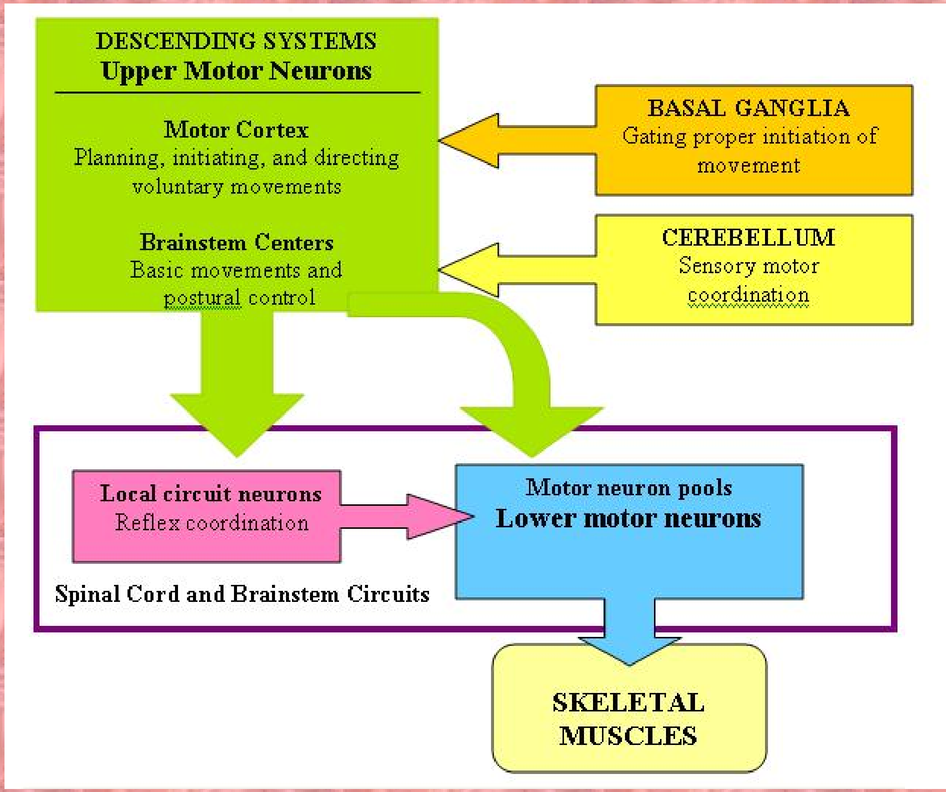
Neural circuits responsible for the control of movement can be divided into four distinct but highly interactive subsystems:

- Descending Modulatory Systems
- Local Spinal Cord and Brainstem Circuits
- Basal Ganglia
- Cerebellum


DESCENDING SYSTEMS
Upper Motor Neurons
Motor Cortex
Planning, initiating, and directing voluntary movements
Brainstem Centers
Basic movements and postural control
BASAL GANGLIA
Gating proper initiation of movement
CEREBELLUM
Sensory motor coordination
Local circuit neurons
Reflex coordination
Motor neuron pools
Lower motor neurons
Spinal Cord and Brainstem Circuits
SKELETAL MUSCLES

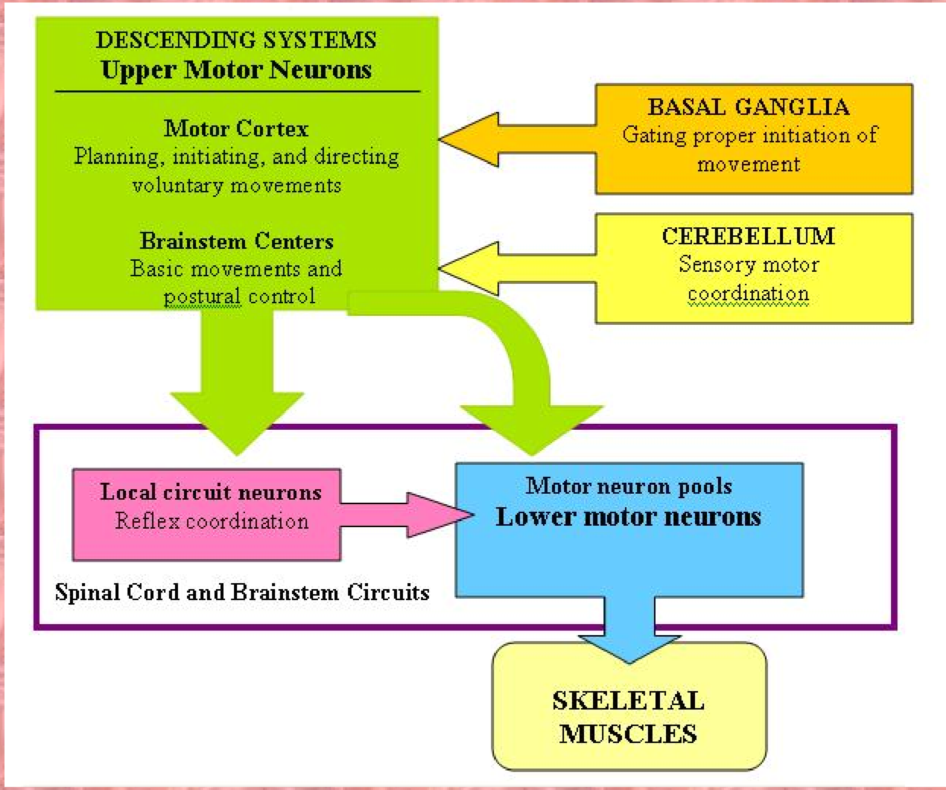
Descending Modulatory Pathways (Upper Motor Neurons)

- The cell bodies for these pathways lie in the brainstem or cerebral cortex and descend to synapse with the local circuit neurons or, more rarely, with lower motor neurons directly.



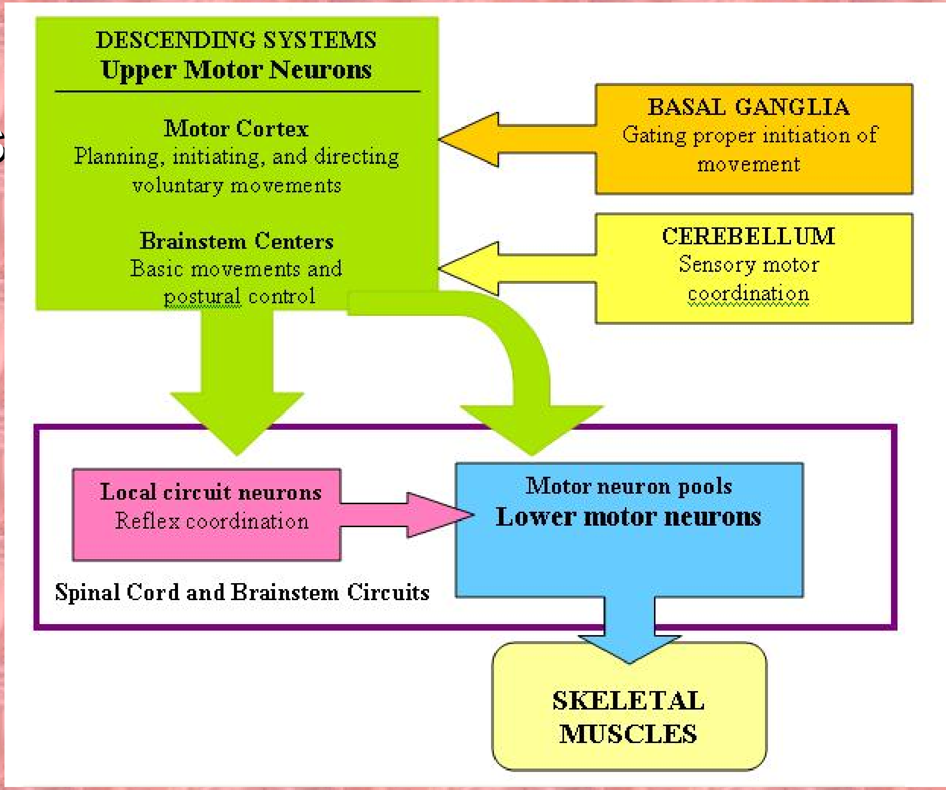
Descending Modulatory Pathways (Upper Motor Neurons)

- Motor cortex pathways descending from areas such as the primary motor cortex, the lateral premotor cortex, and the medial premotor cortex, are required for the planning, initiation and direction of temporal sequences of voluntary movement.
- Brainstem pathways are responsible for regulating muscle tone and for orienting the eyes, head and body with respect to vestibular, somatic, auditory and visual sensory information.



Local Spinal Cord and Brainstem Circuits

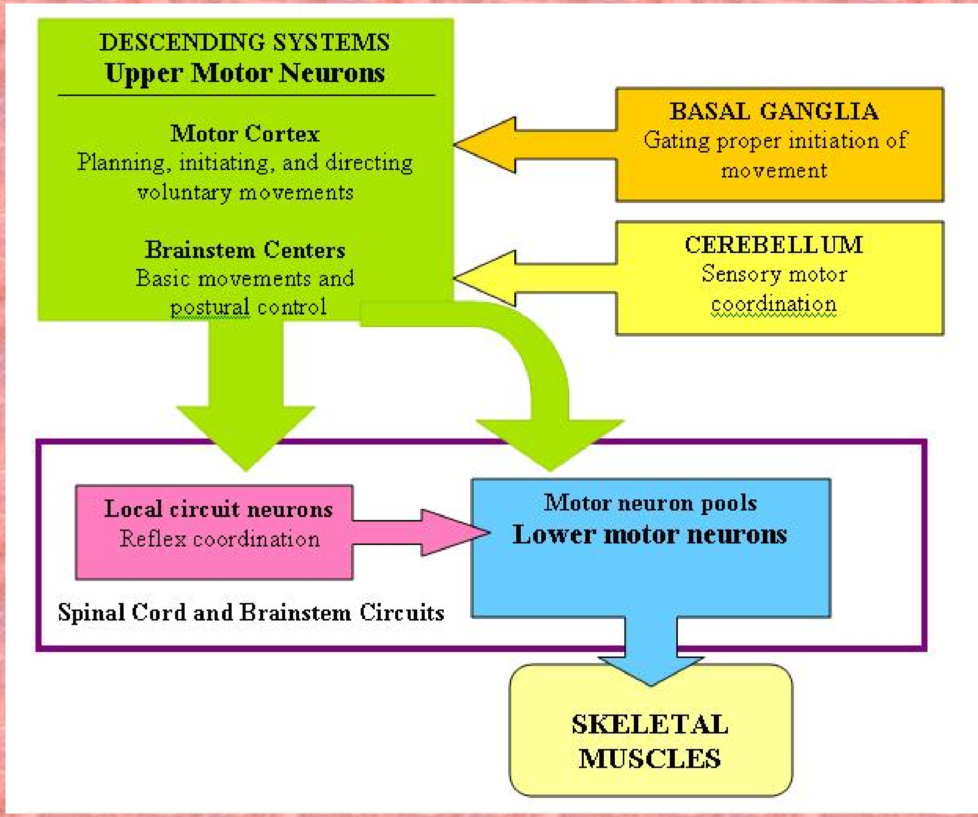
- Lower motor neurons send their axons out of the brainstem to innervate muscles of the head and neck and to innervate muscles of the body.
- Local circuit neurons receive sensory inputs as well as descending projections from higher centers and provide the coordination between different muscle groups essential for organized movement
  - they are the major source of synaptic input to the lower motor neurons.



Local Spinal Cord and Brainstem Circuits

Cerebellum

- detects motor error which are differences between an intended movement and the movement actually performed, and provides input to upper motor neurons.



Basal Ganglia

- suppress unwanted movement and primes upper motor neuron circuits for movement initiation.

DESCENDING MODULATORY PATHWAYS (UPPER MOTOR NEURONS)

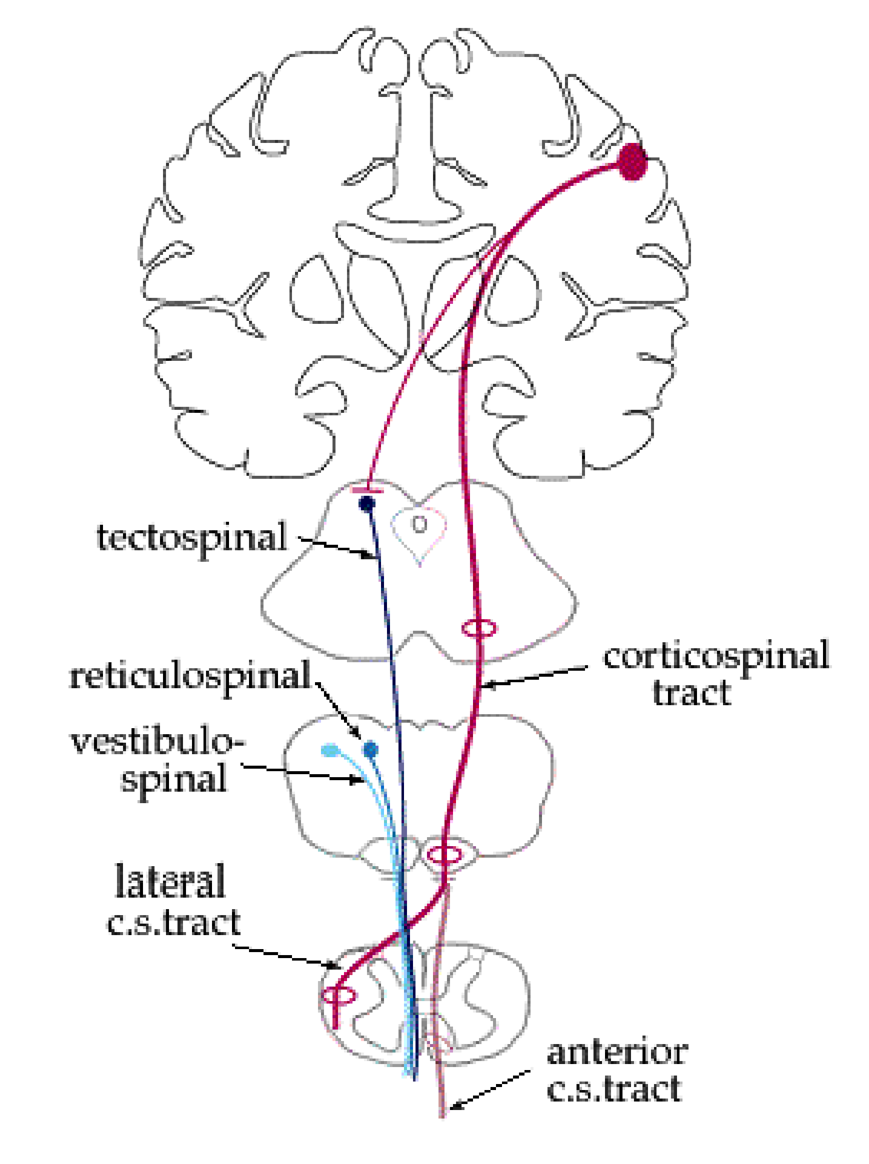
Upper motor neurons influence the spinal cord by two routes:

1) direct projections to the spinal cord (ventral corticospinal tract; lateral corticospinal tract)

2) indirect projections to brainstem centers that in turn project to the spinal cord (e.g. corticoreticulospinal tract)

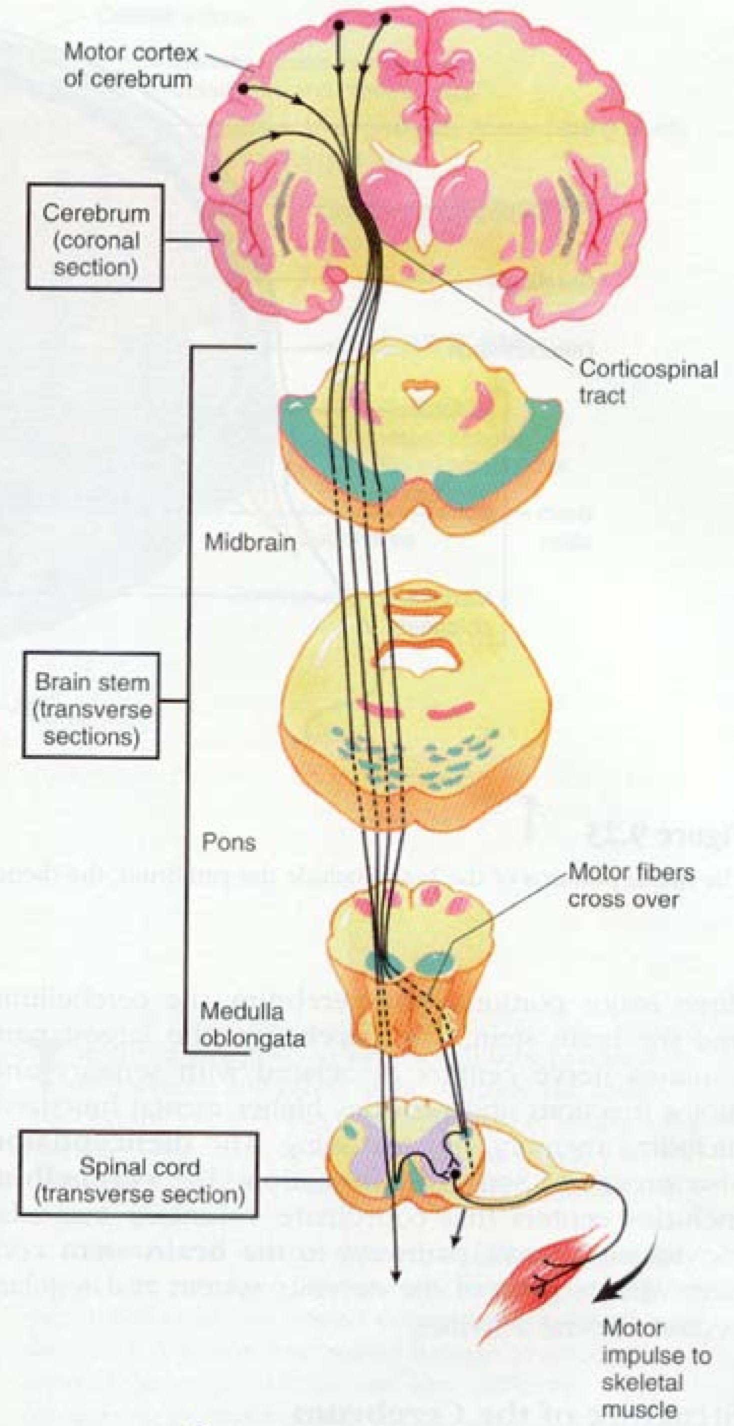
Spinal Motor Tracts

- There are several pathways which innervate the alpha-motor neurons.
- can be roughly grouped into the
  - voluntary (direct projection) motion pathways
    - lateral and anterior corticospinal systems (pyramidal tracts)
  - postural pathways.(extrapyramidal, indirect projection)
    - pathways do not originate in cortex
    - their function is to maintain an upright posture against gravity
    - There are three principal pathways in humans: the vestibulospinal, tectospinal, and reticulospinal pathways.
    - rubrospinal system (from the red nucleus) is also sometimes included, but in humans it may be insignificant.



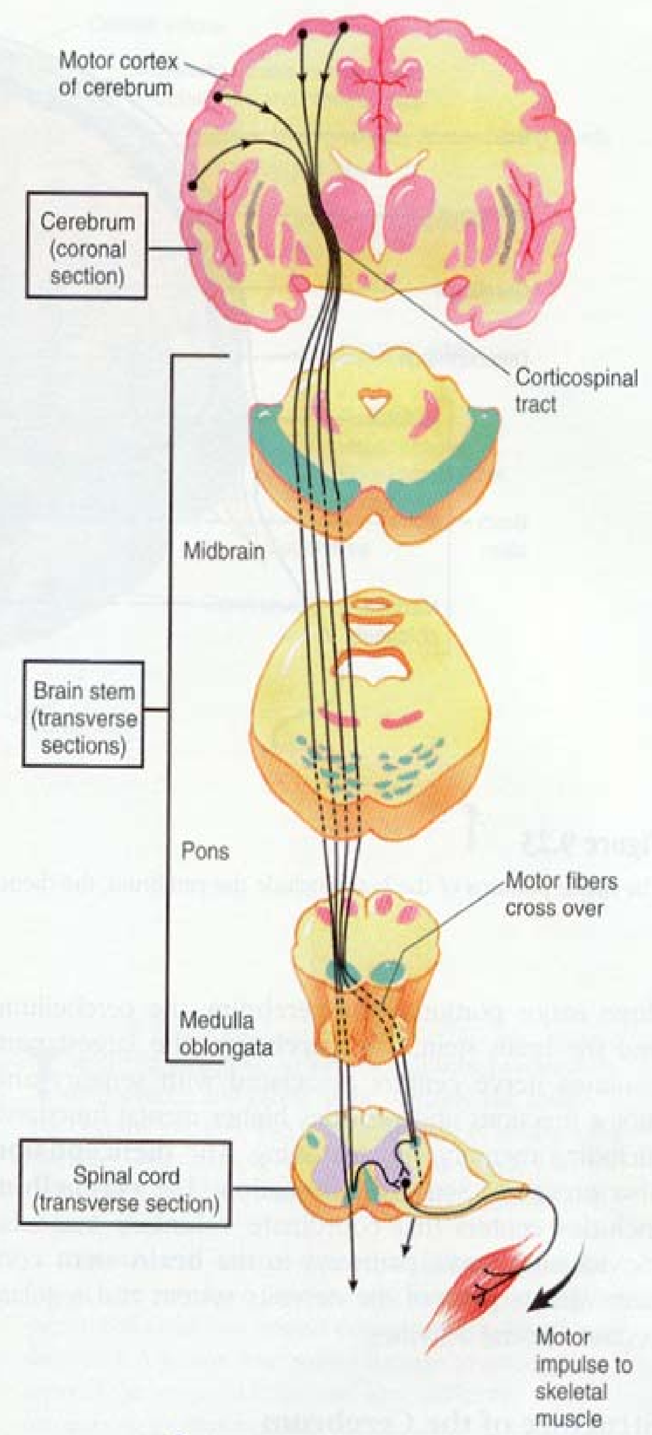
Pyramidal Motor System (Corticospinal Tract)

- controls all our voluntary movement via a two-neuron system:
  - upper motor neurons in the primary motor cortex
    - upper motor neuron axon extends all the way from the brain down to the spinal cord, a distance 1-3 feet or more
  - lower motor neurons in the anterior horn of the spinal cord.
    - axon extends from the spinal cord to the skeletal muscles of the arms or legs, a distance 4-5 feet in very tall people.



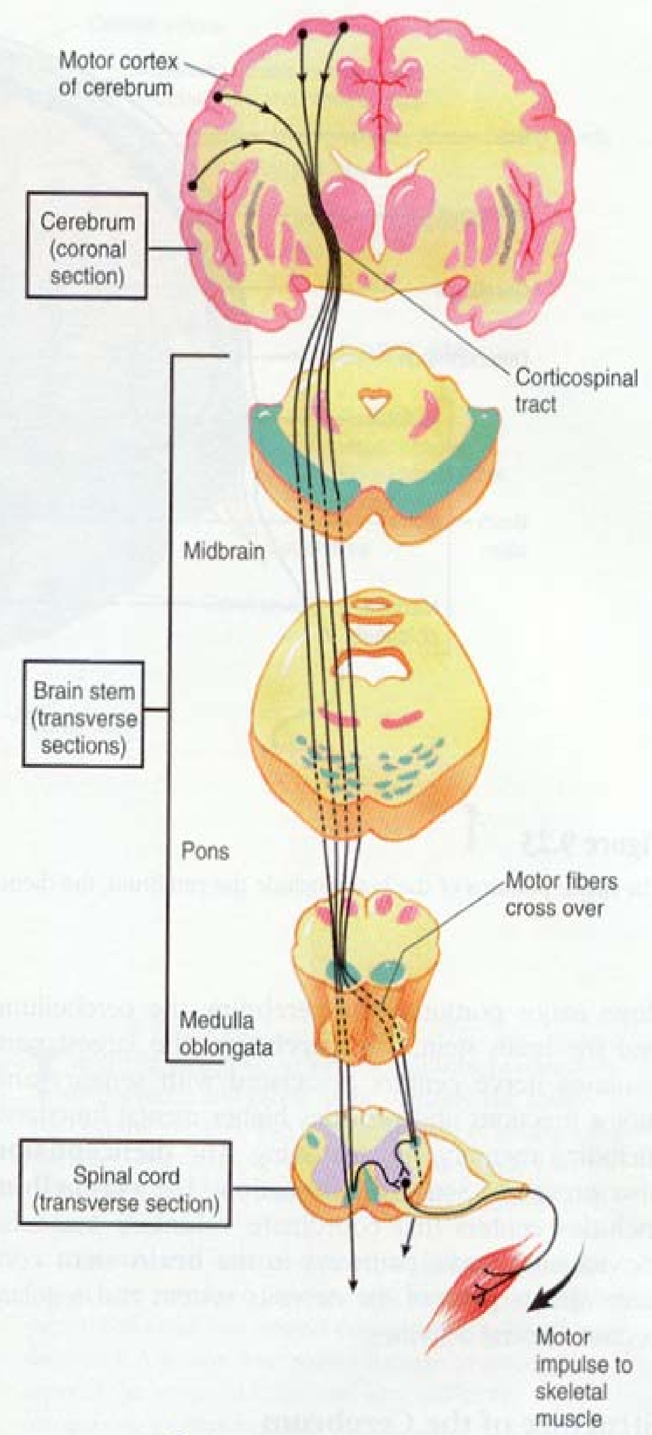
Corticospinal Tract

- Upper motor neurons pass from the motor cortex
- through the internal capsule of the forebrain, cerebral peduncle at the base of the midbrain,
- scatter through the base of the pons
- coalesce on the ventral surface of the medulla to form the medullary pyramids.



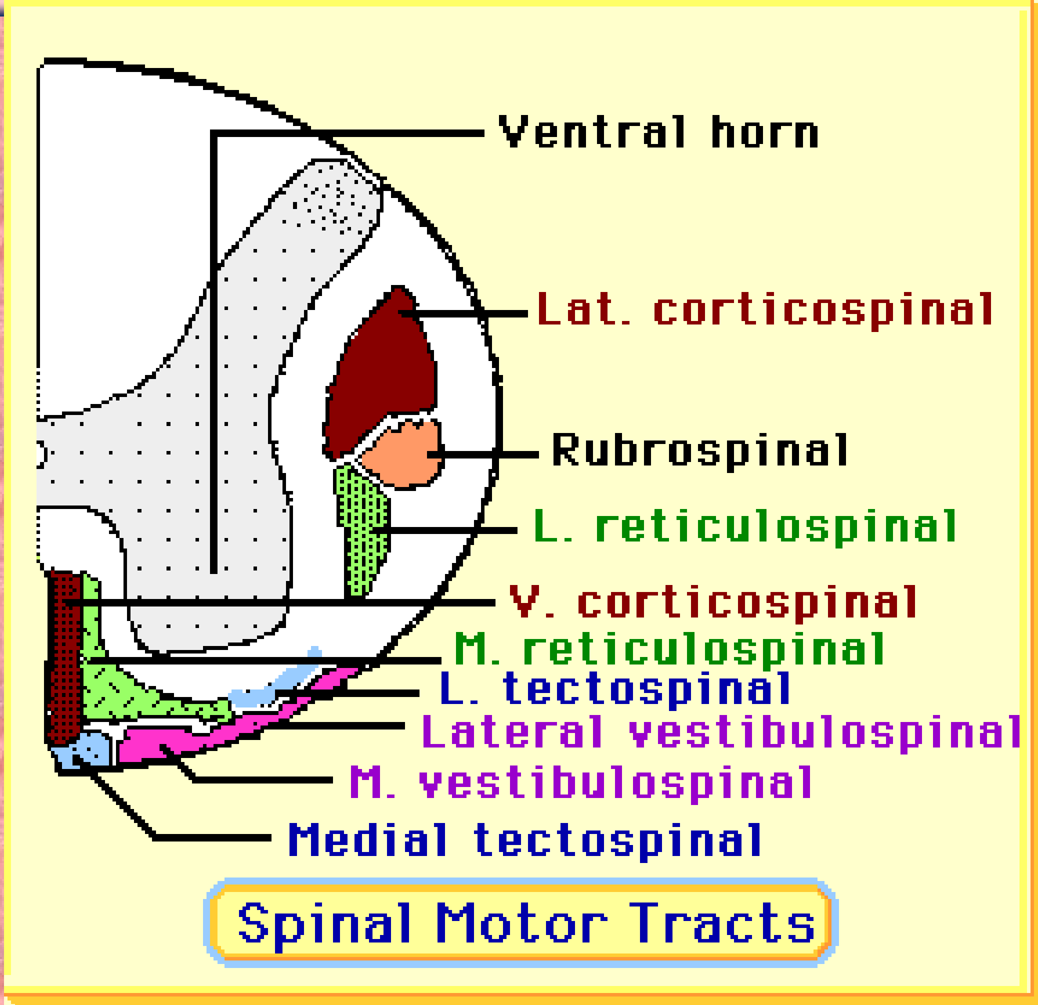
Corticospinal Tract

- 80 - 90 % of corticospinal tract axons cross to the other side in the distal medulla forming the lateral corticospinal tract.
- The pyramidal decussation separates the medulla,above, from the spinal cord, below.
- The Ventral Corticospinal tract contains the axons from the 10-20% of neurons whose axons did not cross to the other side at the pyramidal decussation.
- The upper motor neuron axons then synapse on lower motor neurons in the Anterior horn of the spinal cord.
- The axons of these lower motor neurons then exit the spinal cord via the Ventral root. Damage to LMN's causes flaccid paralysis.



Extrapyramidal Tracts

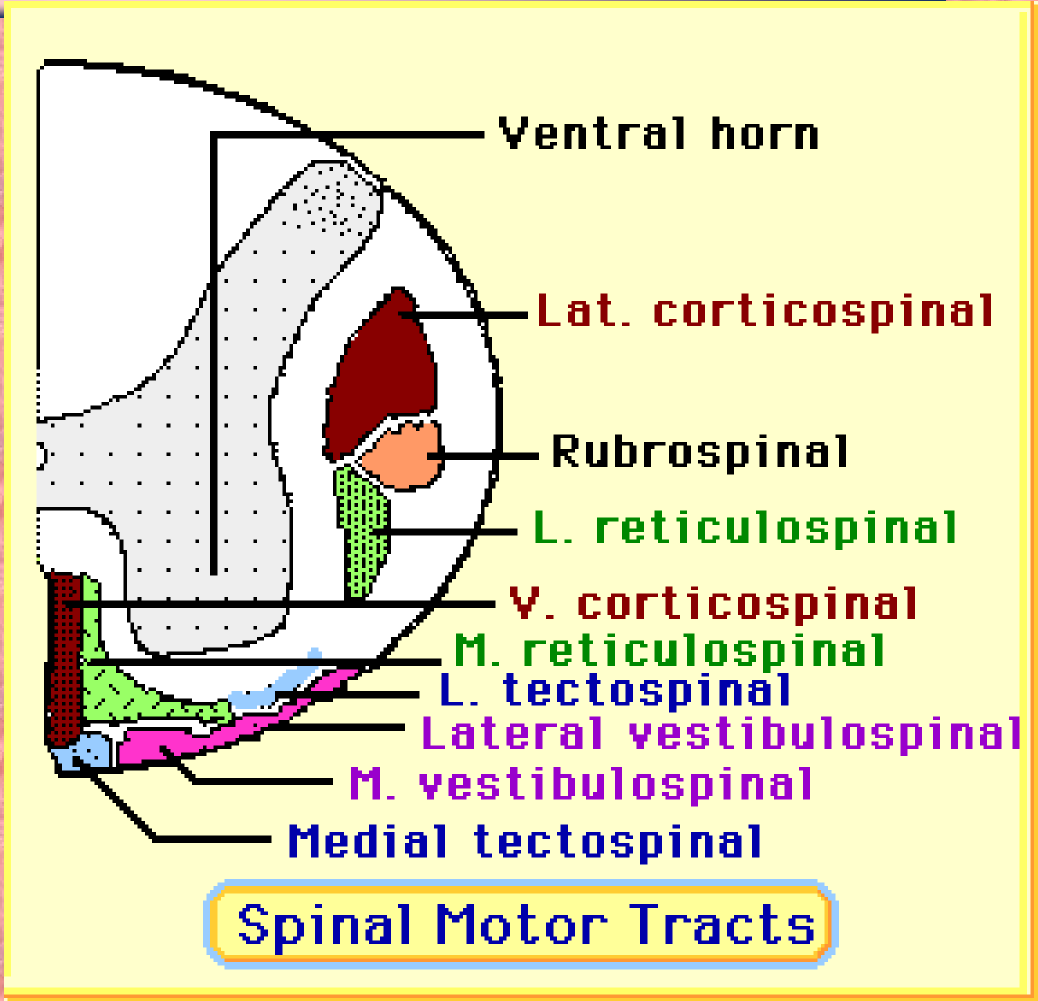
- Tectospinal tracts are found in cervical cord segments only.
- begins in the midbrain retion called the tectum
- axons synapse onto motor horn cells innervating muscles that move the head
- involved in reflex movements of head in response to visual and auditory stimuli



Extrapyramidal Tracts

Lateral & Medial Reticulospinal tract

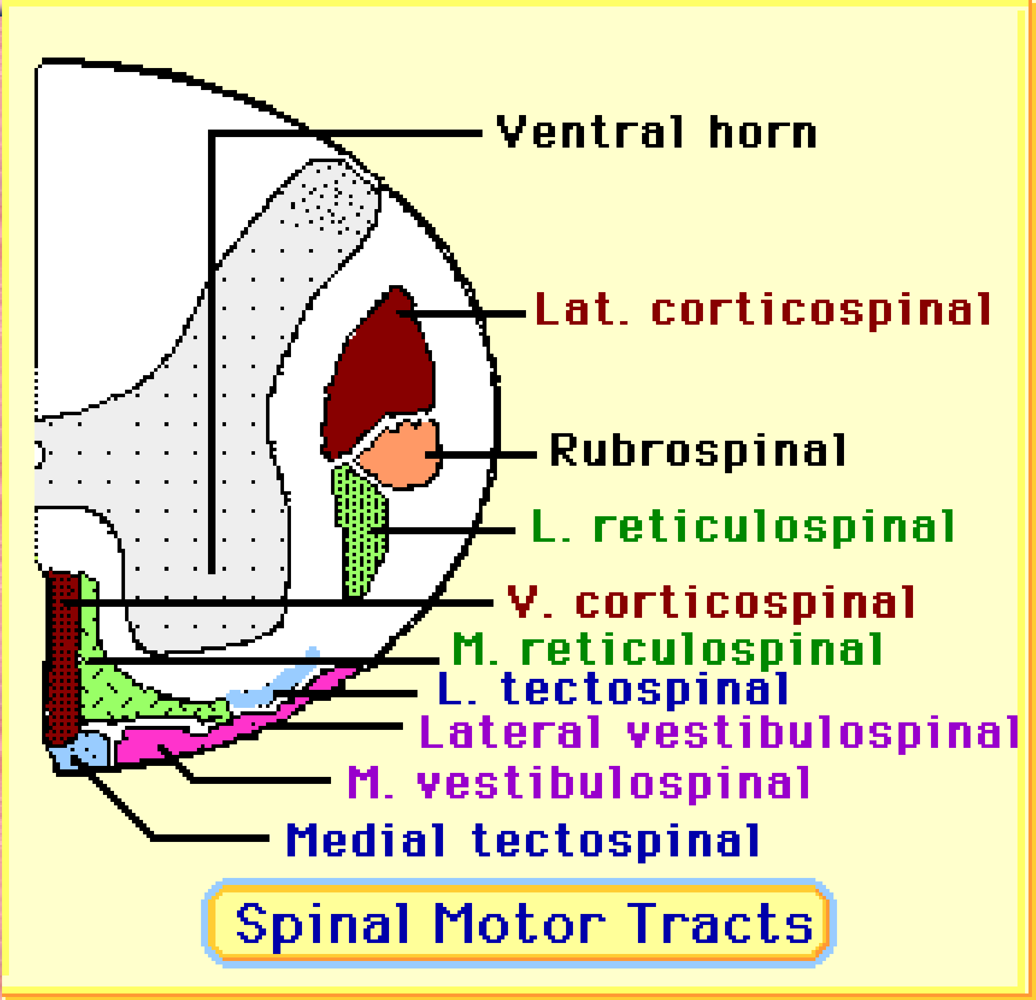
- tract originates in the reticular formation of the brainstem
- involved in the muscles that control posture and balance
- also contain descending analgesic pathways that reduce transmission of pain signals to the brain
- the principal function of the reticulospinal tracts is to provide efferent signals to the lateral horn of the gray matter--the autonomic pre-ganglionic fibers. This includes both the sympathetic outflow as well as the sacral parasympathetics.



Extrapyramidal Tracts

Vestibulospinal tract

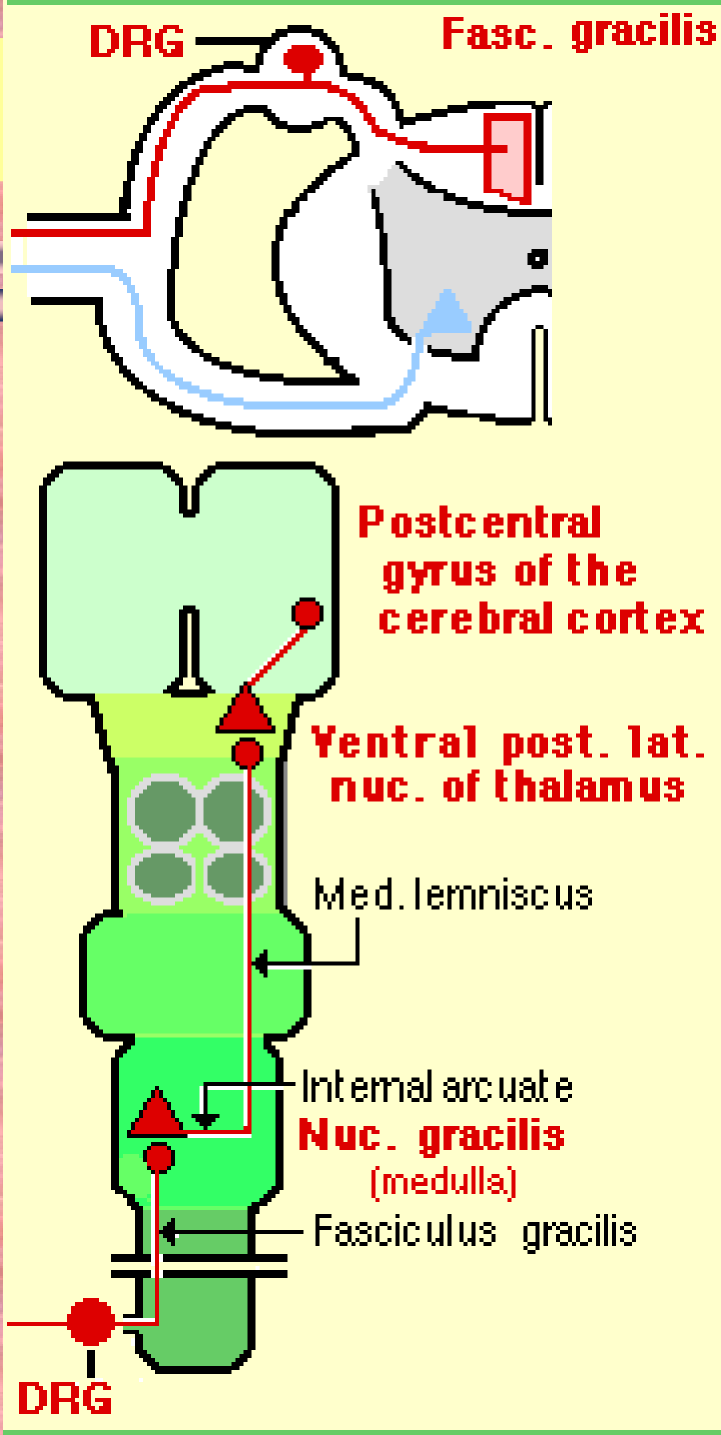
- Cells are located in vestibular nuclei of the medulla, and they synapse onto lower motor horn circuits of locomotor and trunk musculature that receives impulses for balance from the inner ear
  - based on saccular, utricular and semicircular duct sensation--inner ear and sense of balance/acceleration.
- controls limb muscles that maintain balance and posture



Spinal Sensory Pathways

Fasciculus gracilis

- The majority of the fibers do not synapse until they reach the medulla.
- These fibers arise in dorsal root ganglia of sacral and lumbar segments of the spinal cord.
- Presynaptic fibers are routed to the nucleus gracilis.
- The gracile nucleus lies medial to the cuneate nucleus on each side.
- The postsynaptic paths of cuneatus and gracilis are parallel from this point.
- When 3° gracilis axons reach cerebral cortical level, they are directed to the dorsal side of the cerebral hemisphere, whereas the cuneate data is sent to the lateral and ventral part of the gyrus.



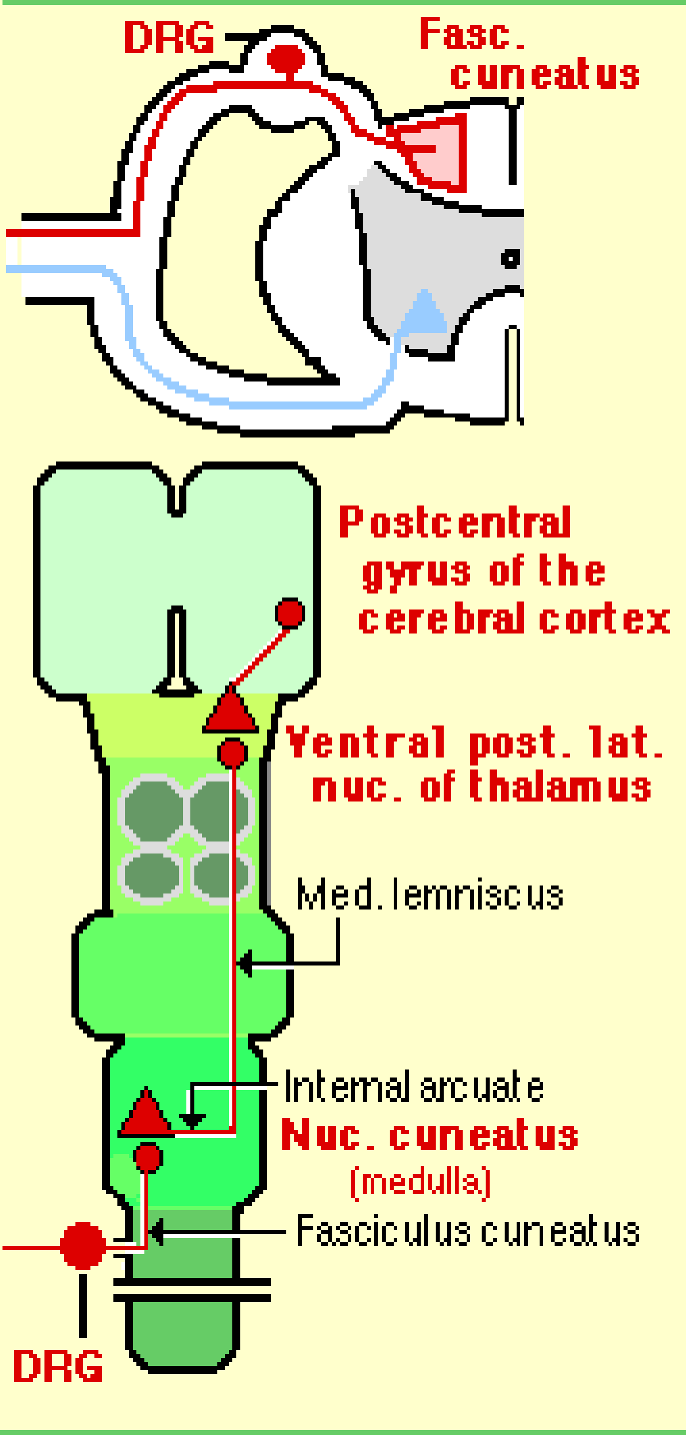
Spiral Sensory Pathways

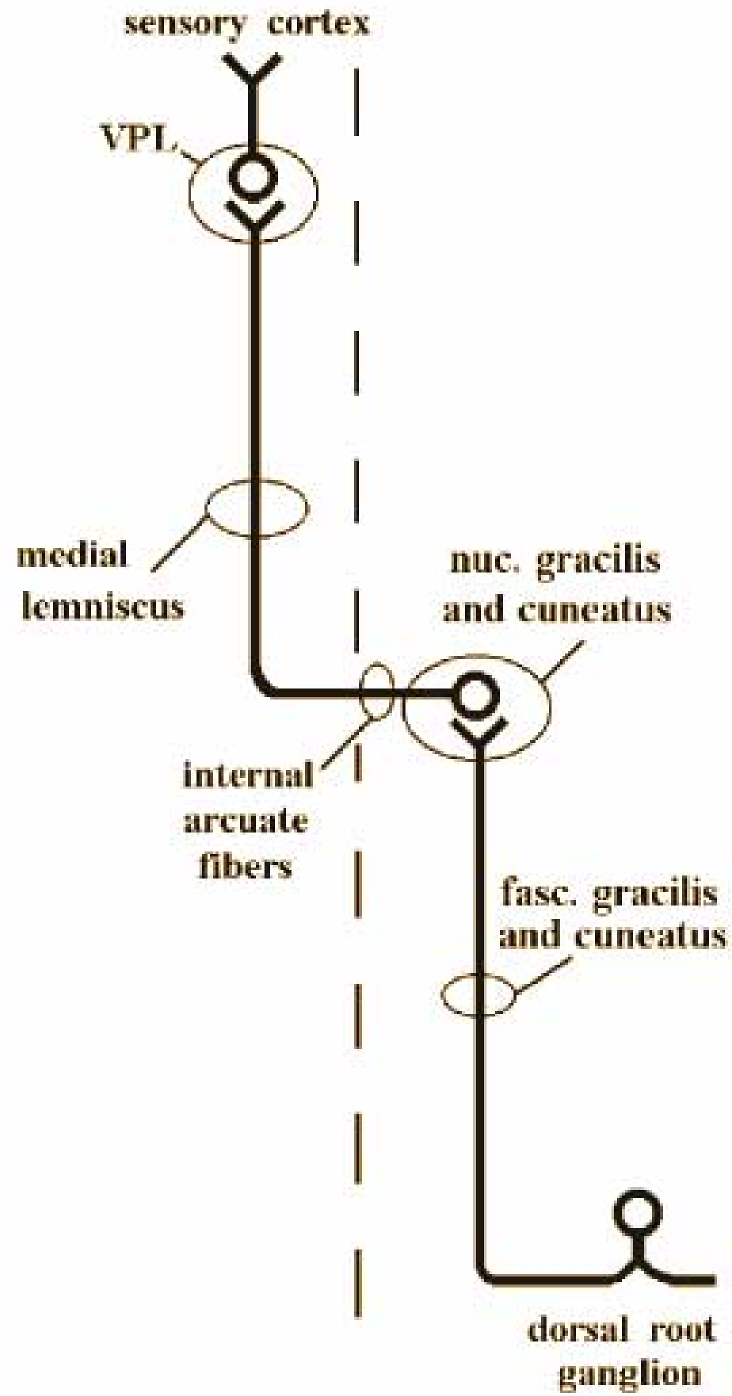
fasciculus cuneatus

- Cuneate axons ascend in the dorsal cord on the ipsilateral side and synapse in the nucleus cuneatus in the dorsal lateral medulla.
- Postsynaptic fibers cross immediately to the contralateral side via bands of axons known as the 'internal arcuate fibers' and enter the massive ascending pathway, the medial lemniscus.
- Lemniscal axons ascend without synapse until they reach the ventral posterior lateral nucleus (VPL) of the thalamus.

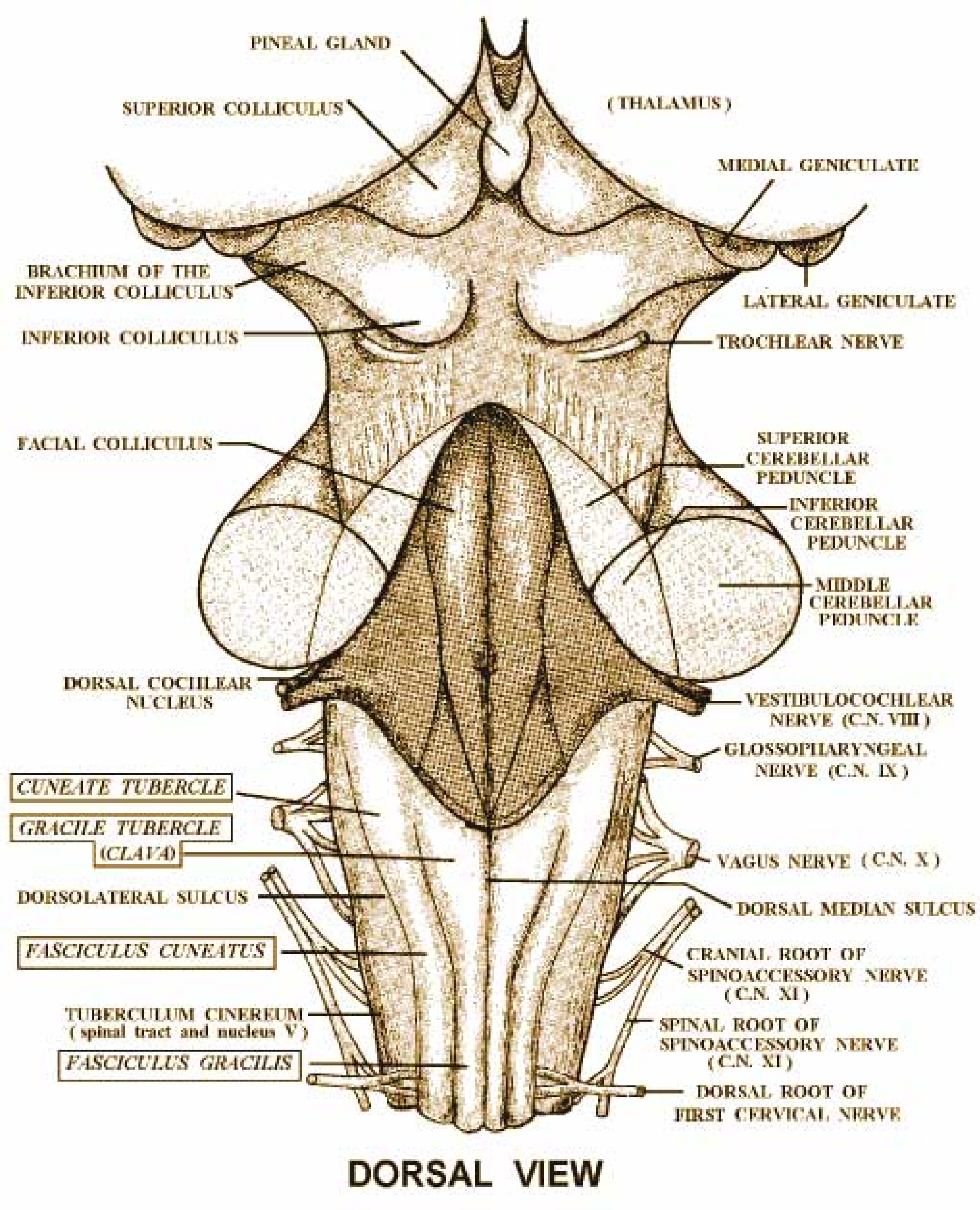
  (All sensory input to the brain, with the exception of olfactory, is processed in the thalamus)

- Axons arising in VPL ascend to the cerebral cortex in the postcentral gyrus (Brodeman areas 1, 2, 3, and 5), where 'local sign' of touch sensation is recognized.




sensory cortex
VPL
medial lemniscus
nuc. gracilis and cuneatus
internal arcuate fibers
fasc. gracilis and cuneatus
dorsal root ganglion

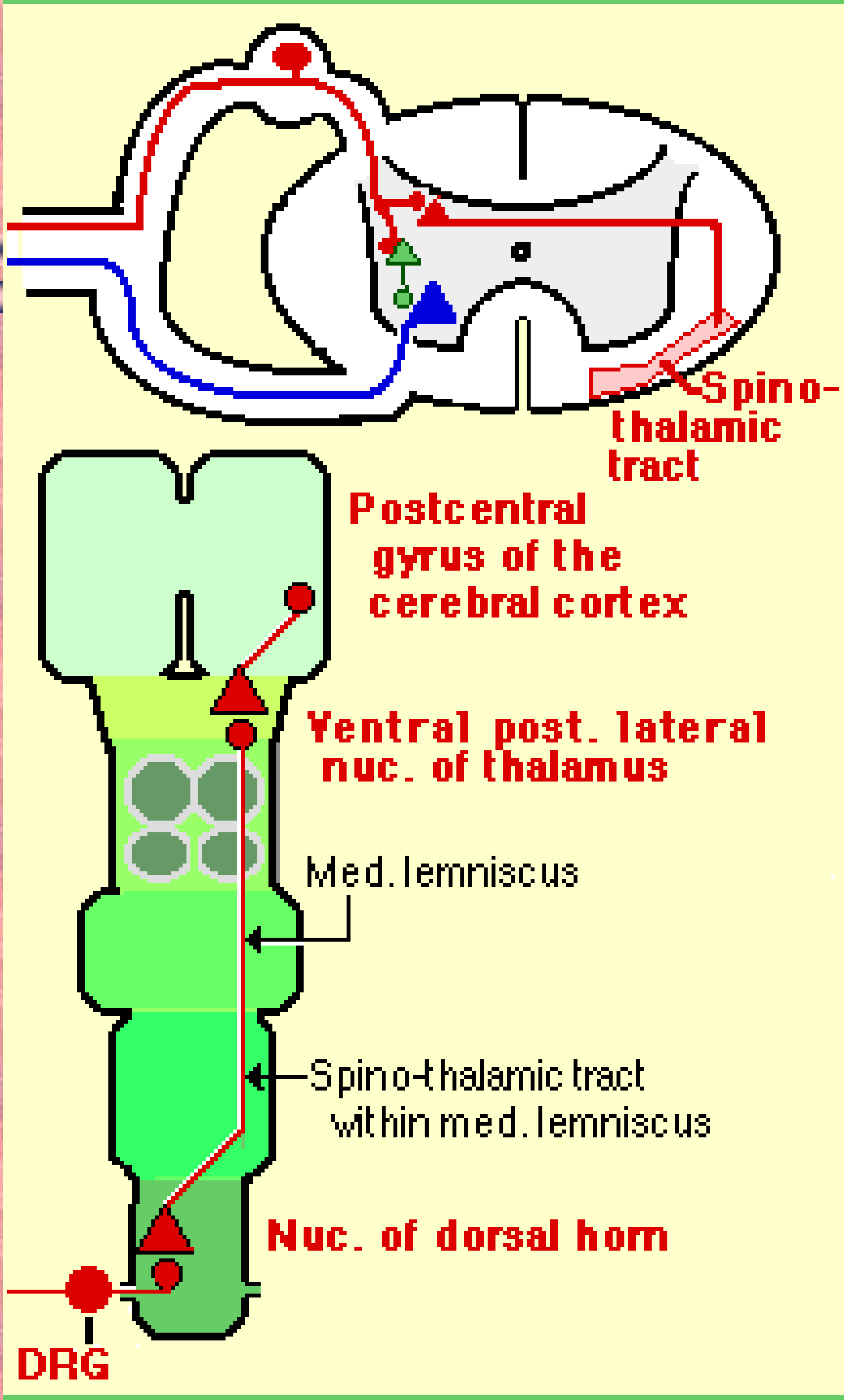
- These two nuclear groups and their associated fasciculi can be seen as slight swellings on the dorsal surface of the medulla.
- The bump formed by nucleus and fasciculus gracilis is called the gracile tubercle
- and that caused by nucleus and fasciculus cuneatus is called the cuneate tubercle.



Spinal Sensory Pathways

Lateral Spinothalamic Tracts

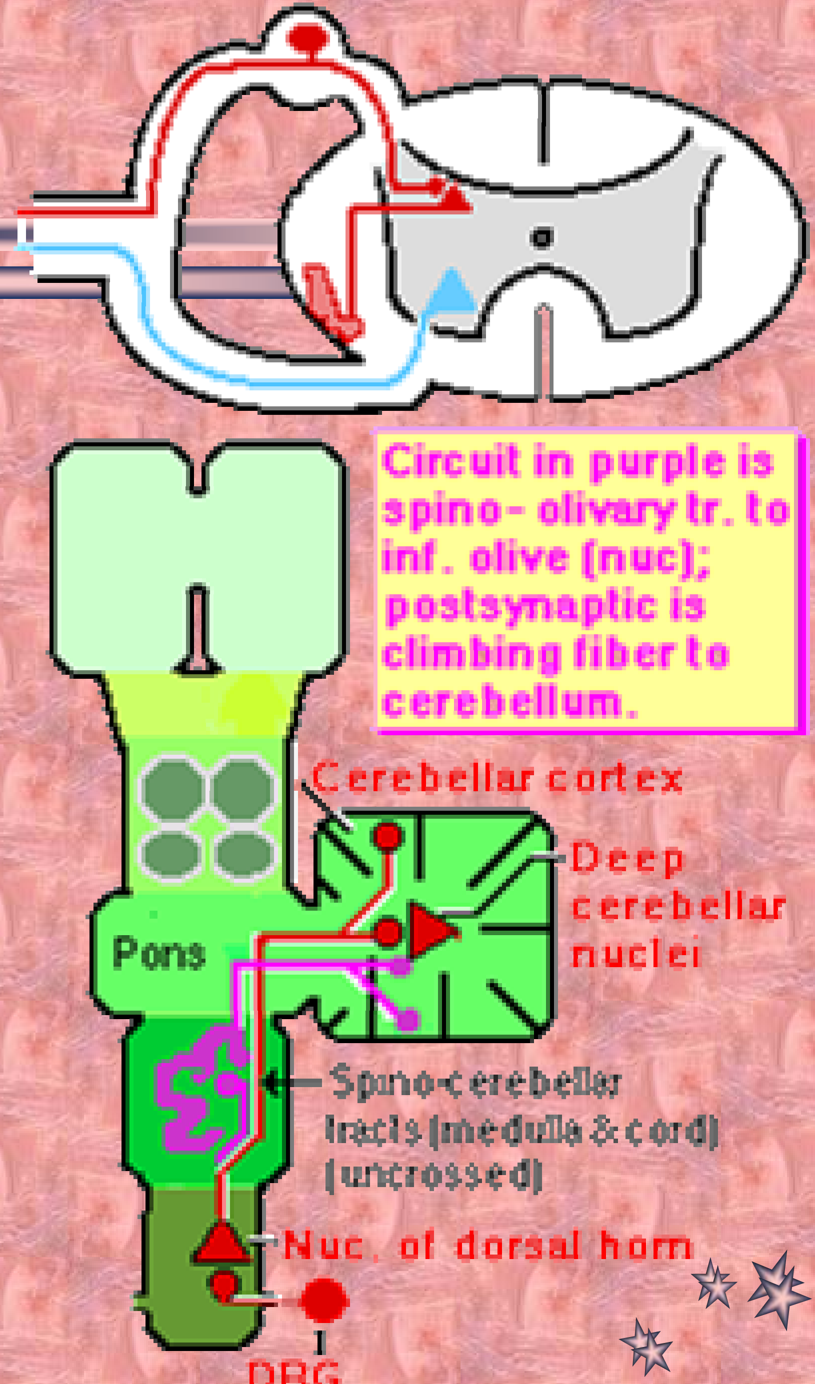
- principal pathways pain, temperature, pressure, tickle, itch, and light or crude touch.
    - light touch-sensation produced by stroking hairless skin with a feather or cotton wisp
    - crude touch- location can only vaguely identify
- Pain fibers are small and usually unmyelinated, while thermal fibers usually have myelin.
- first order neurons synapsis occurs in the dorsal horn
- Postsynaptic (second order) neurons decussate to form the ascending spinothalamic tract.
- They ascend through the lower brain stem in the medial lemniscus.



Spinal Sensory Pathways

Dorsal and Ventral Spinocerebellar Pathways

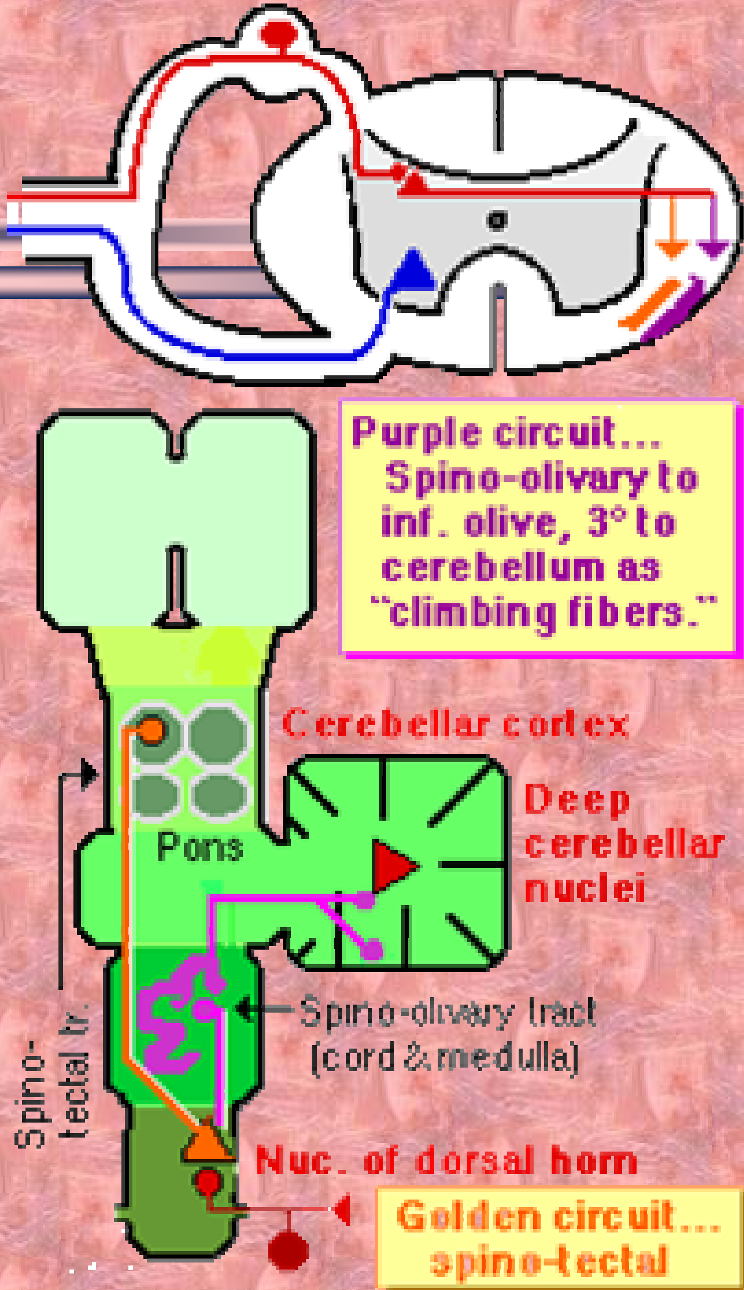
- Spinocerebellar fibers carry proprioceptive signals from the limbs and trunk to the cerebellum
- After synapsing in the dorsal gray horn, 2° axons ascend in the dorsal or ventral spinocerebellar tracts.
  - dorsal tract travel ipsilateral
  - ventral cross, ascend, cross back in brainstem to enter ipsilateral Cerebellum
- enter the cerebellum as mossy fibers, and the next level of synapses is there, in the deep cerebellar nuclei and onto the granule cells of the cerebellar cortex



Spinal Sensory Pathways

Spinotectal tract—

- in terms of receptors, this is a spinothalamic subdivision, but it synapses in the sup. colliculus of the mesencephalon, rather than continuing to the thalamus.
- Functionally, it transmits typical spinothalamic impulses (touch) into the tectum, where it drives reflexes, aiming the head (gaze) at the location of sensory input on the body surface (a bee stings, you rapidly look at the bee!).



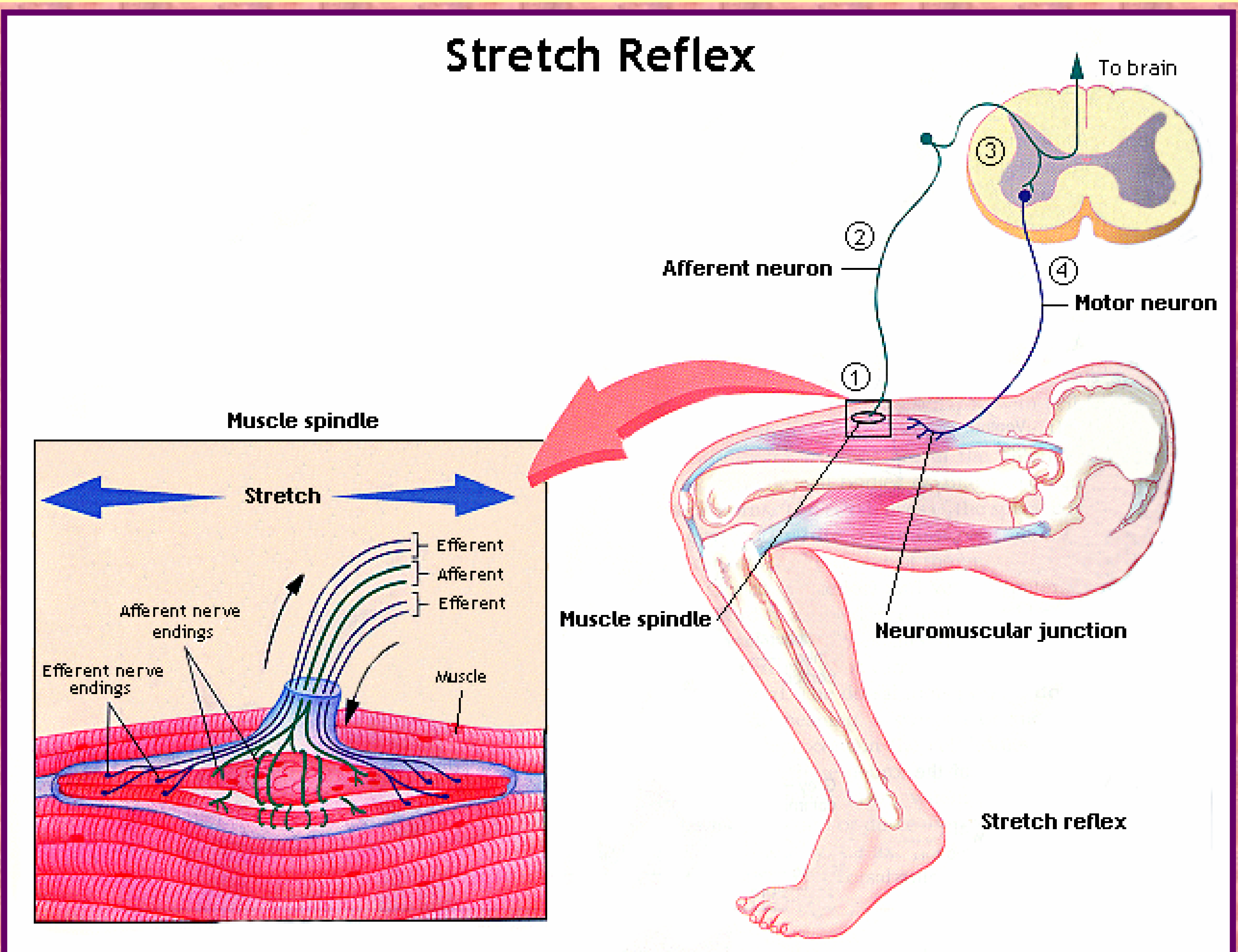
Reflex Actions

- **An automatic response to a specific stimulus**
- **Reflex Arcs**
  - **Most don’t involve conscious thought**
  - **Some involve lower brain**
  - **Some are carried out by the spinal cord without any brain involvement**

Types of Reflexes

- **Monosynaptic Reflexes**
  - **Chain of only 2 neurons involved**
    - **Example: Patellar reflex (stretch reflex)**
      - **Quadriceps tendon stretched ➡ muscle spindles send impulse (muscle stretching) ➡ spinal cord ➡ motor neuron ➡ quadriceps muscle contracts**

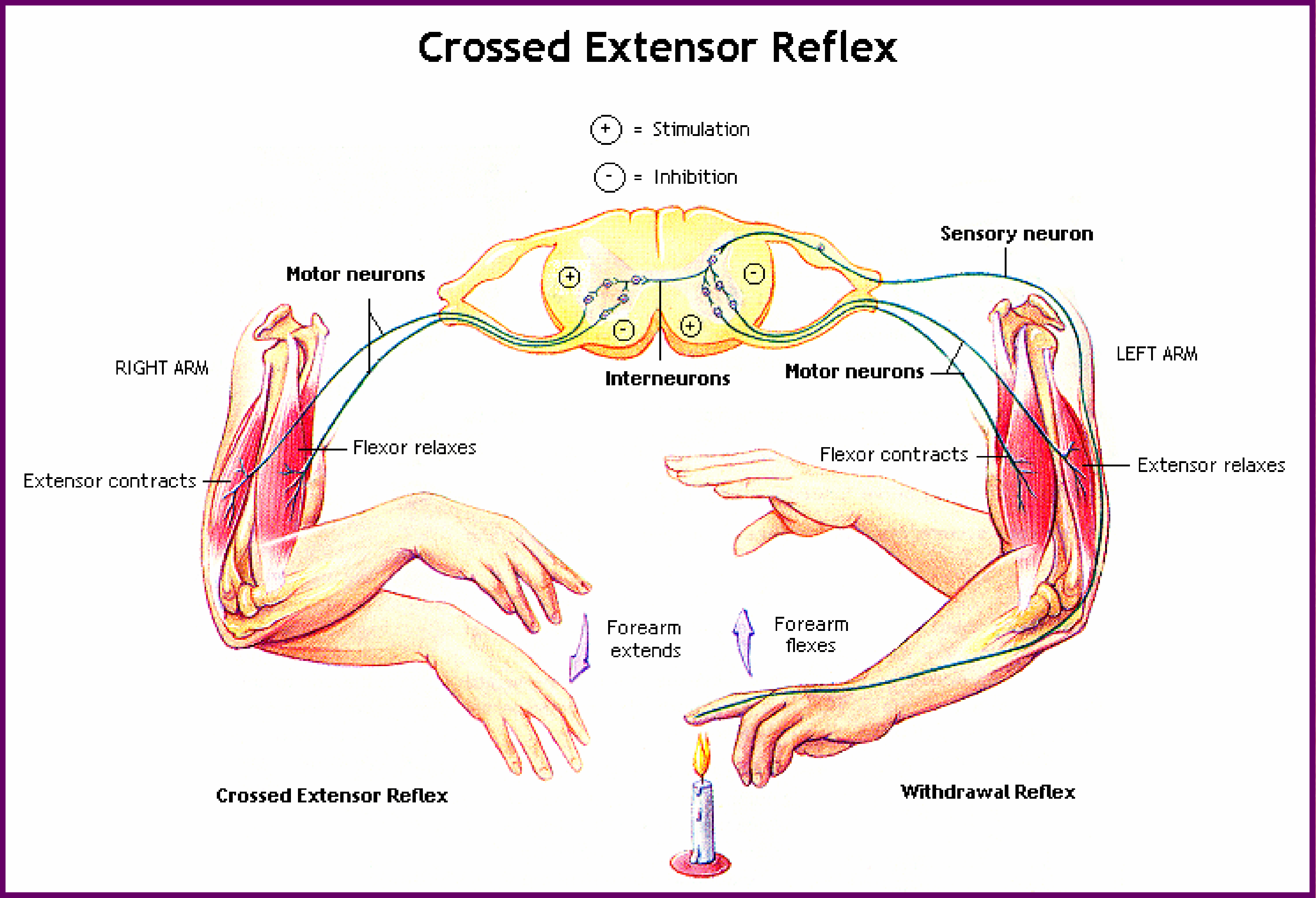
Stretch Reflex



Types of Reflex

- Polysynaptic Reflexes
  - Require 3 or more sets of neurons
    - Example: Withdrawal reflex (crossed extensor reflex)
      - Pain receptors ➡ spinal cord ➡ association neuron ➡ integration ➡ motor neurons (to muscles for contraction) ➡ flexors contract ➡ extensors extend for balance

Crossed Extensor Reflex



Referred Pain

- **Perceived by the brain as pain from an extremity or body region rather than visceral pain**

Diseases and Disorders

- **Ataxia**
  - Staggering gait, slurred speech, overshooting of target when touching things
  - May result from damage to cerebellum
- **Cerebrovascular Accidents (Strokes)**
  - Caused by lack of blood to the brain
  - Possible blockage of a cerebral artery or rupture of an aneurysm

Diseases and disorders

- **Transient Ischemic Attacks (TIA's)**
  - Temporary blood deprivation lasting from 5 to 50 min.
  - Temporary numbness, paralysis, or impaired speech
  - Usually warning of an impending, more serious stroke
- **Alzheimer's Disease**
  - Progressive degeneration of brain function
  - Deficit of Ach
  - Memory loss, shortened attention span, disorientation, possible language loss

Diseases and disorders

- **Parkinson's Disease**
  - **Degeneration of dopamine releasing neurons**
  - **Basal ganglia become deprived of dopamine**
  - **Persistent tremors, forward bent posture when walking and shuffling gait**

Diseases and Disorders

- **Huntington's Disease**
  - **Hereditary**
  - **Massive degeneration of the basal ganglia and eventually the cerebral cortex**
  - **Causes spastic, abrupt, jerky movements**
  - **Mental deterioration and death result**